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IDENTIFIERS	Military Curriculum Project

ABSTRACT

This course, adapted from military curriculum materials for use in vocational and technical education, was designed to upgrade an apprentice weather observer to the weather observer specialist level. Intended to be used in a laboratory or on-the-job learning situation, it contains both basic information needed for review and supervisory information. The course is divided into four volumes with accompanying student workbooks. Volume 1 on unit operations, equipment, and special topics contains two chapters covering meteorology, mathematics, and weather station equipment; while the second volume on surface weather observations and station operations contains two chapters covering observations as well as encoding and disseminating surface observations, with practice charts attached. In the third volume on weather plotting and communications, three chapters cover plotting weather charts, weather communications, as well as editing and electronic data processing. A supplemental volume of charts accompanies the volume. The final volume on upper air observations and tactical stations contains three chapters discussing pilot balloon observations, Rawinsonde Observations, and Rocketsonde and Dropsonde Observations. Each chapter contains objectives. readings, exercises, and answers for student self-study and evaluation. Volume review exercises (without answers) are available. Used in a self-study situation, the course is planned to give some background and advanced information on specific procedures used in meteorology and weather observation. (KC)

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MILITARY CURRICULUM MATERIALS

The military-developed curriculum materials in this course package were selected by the National Center for Research in Vocational Education Military Curriculum Project for dissemination to the six regional Curriculum Coordination Centers and other instructional materials agencies. The purpose of disseminating these courses was to make curriculum materials developed by the military more accessible to vocational educators in the civilian setting.

The course materials were acquired, evaluated by project staff and practitioners in the field, and prepared for dissemination. Materials which were specific to the military were deleted, copyrighted materials were either omitted or approval for their use was obtained. These course packages contain curriculum resource materials which can be adapted to support vocational instruction and curriculum development.

The National Center Mission Statement

The National Center for Research in Vocational Education's mission is to increase the ability of diverse agencies, institutions, and organizations to solve educational problems relating to individual career planning, preparation, and progression. The National Center fulfills its mission by:

- Generating knowledge through research
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- Conducting leadership development and training programs

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Military Curriculum Materials for Vocational and Technical Education

Information and Field Services Division

The National Center for Research in Vocational Education

Military Curriculum Materials Dissemination Is . . .

an activity to increase the accessibility of military-developed curriculum materials to vocational and technical educators.

This project, funded by the U.S. Office of Education, includes the identification and acquisition of curriculum materials in print form from the Coast Guard, Air Force, Army, Marine Corps and Navy.

Access to military curriculum materials is provided through a "Joint Memorandum of Understanding" between the U.S. Office of Education and the Department of Defense.

The acquired materials are reviewed by staff and subject matter specialists, and courses deemed applicable to vocational and technical education are selected for dissemination.

The National Center for Research in Vocational Education is the U.S. Office of Education's designated representative to acquire the materials and conduct the project activities.

Project Staff:

Wesley E. Budke, Ph.D., Director
National Center Clearinghouse

Shirley A. Chase, Ph.D.
Project Director

What Materials Are Available?

One hundred twenty courses on microfiche (thirteen in paper form) and descriptions of each have been provided to the vocational Curriculum Coordination Centers and other instructional materials agencies for dissemination.

Course materials include programmed instruction, curriculum outlines, instructor guides, student workbooks and technical manuals.

The 120 courses represent the following sixteen vocational subject areas:

- Agriculture
- Aviation
- Building & Construction Trades
- Clerical Occupations
- Communications
- Drafting
- Electronics
- Engine Mechanics
- Food Service
- Health
- Heating & Air Conditioning
- Machine Shop
- Management & Supervision
- Meteorology & Navigation
- Photography
- Public Service

The number of courses and the subject areas represented will expand as additional materials with application to vocational and technical education are identified and selected for dissemination.

How Can These Materials Be Obtained?

Contact the Curriculum Coordination Center in your region for information on obtaining materials (e.g., availability and cost). They will respond to your request directly or refer you to an instructional materials agency closer to you.

CURRICULUM COORDINATION CENTERS

EAST CENTRAL
Rebecca S. Douglass
Director
100 North First Street
Springfield, IL 62777
217/782-0759

MIDWEST
Robert Patton
Director
1515 West Sixth Ave.
Stillwater, OK 74704
405/377-2000

NORTHEAST
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Trenton, NJ 08625
609/292-6562

NORTHWEST
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Building 17
Airdustrial Park
Olympia, WA 98504
206/753-0879

SOUTHEAST
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Mississippi State, MS 39762
601/325-2510

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1776 University Ave.
Honolulu, HI 96822
808/948-7834

WEATHER OBSERVER

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WEATHER OBSERVER

Correspondence Course

15-1

Developed by:

United States Air Force

Development and Review Dates

May 1975

Occupational Area:

Meteorology and Navigation

Cost:

Print Pages:

517

Availability:

Military Curriculum Project, The Center for Vocational Education, 1960 Kenny Rd., Columbus, OH 43210

Suggested Background:

None

Target Audiences:

Grades 10-adult

Organization of Materials:

Student workbooks with objectives, assignments, review exercises and answers, and volume review exercises; text; supplementary charts

Type of Instruction:

Individualized, self-paced

Type of Materials:		**No. of Pages:**	**Average Completion Time:**
Volume 1 –	*Unit Operation, Equipment and Special Topics*	93	Flexible
	Workbook	39	
Volume 2 –	*Surface Weather Observations and Station Operations*	85	Flexible
	Workbook	50	
Volume 3 –	*Weather Plotting and Communications*	65	Flexible
	Workbook	45	
	Supplementary Charts	11	
Volume 4 –	*Upper Air Observations and Tactical Stations*	67	Flexible
	Workbook	30	

Supplementary Materials Required:

None

THE CENTER FOR VOCATIONAL EDUCATION
THE OHIO STATE UNIVERSITY

Expires July 1, 1978

Course Description

This course was designed to upgrade an Apprentice (semi-skilled) Weather Observer to the Weather Observer Specialist (skilled) level. It contains the basic information needed for review plus supervisory information. The course is divided into four volumes with accompanying student workbooks.

Volume 1	–	*Unit Operation, Equipment, and Special Topics* contains two chapters covering meteorology, mathematics, and weather station equipment. The first chapter deals with military career services and was deleted. The chapter on equipment contains references to military codes for equipment, but the functions are recognizable in a civilian setting.
Volume 2	–	*Surface Weather Observations and Station Operations* contains two chapters covering surface weather observations and encoding and disseminating surface observations. A third chapter dealing with station administration and supply was deleted because of references to military forms and procedures. Practice charts are attached.
Volume 3	–	*Weather Plotting and Communications* contains three chapters covering plotting weather charts, weather communications and editing and electronic data processing. A supplemental volume of charts accompanies this volume.
Volume 4	–	*Upper Air Observations and Tactical Stations* contains three chapters discussing pilot balloon observations, Rawinsonde Observations, and Rocketsonde and Dropsonde Observations. The fourth chapter on tactical weather sets was deleted.

Each chapter contains objectives, readings, exercises and answers for student self-study and evaluation. Volume review exercises are available but no answers are provided. This course was designed to give some background and advanced information on specific procedures used in meteorology and weather observation. It would best be used in a laboratory or on-the-job learning situation.

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CDC 25251

WEATHER OBSERVER

(AFSC 25251)

Volume 1

Unit Operation, Equipment, and Special Topics

15-1

Extension Course Institute

Air University

11

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DEPARTMENT OF THE AIR FORCE
UNITED STATES OF AMERICA

PREPARED BY
DEPARTMENT OF WEATHER TRAINING
3345TH TECHNICAL SCHOOL (ATC)
CHANUTE AFB, ILLINOIS 61868

EXTENSION COURSE INSTITUTE, GUNTER AIR FORCE BASE, ALABAMA 36114

THIS PUBLICATION HAS BEEN REVIEWED AND APPROVED BY COMPETENT PERSONNEL OF THE PREPARING COMMAND IN ACCORDANCE WITH CURRENT DIRECTIVES ON DOCTRINE, POLICY, ESSENTIALITY, PROPRIETY, AND QUALITY.

Preface

CDC 25251, *Weather Observer*, furnishes the information that you need to perform your job and to progress in the Airman Weather Career Field. The course consists of four volumes: Volume 1, *Unit Operation, Equipment, and Special Topics;* Volume 2, *Surface Weather Observations and Station Operations;* Volume 3, *Weather Plotting and Communications;* and Volume 4, *Upper Air Observations and Tactical Stations.*

Volume 1—a three-chapter volume—has several purposes: to review briefly the general information related to the Airman Weather Career Field and to increase your knowledge of basic meteorology and to cover the areas of mathematics, training management and supervision, and weather station equipment, that will aid you in your duties as a weather observer. Chapter 1 of this volume describes the duties of personnel assigned in this career field, with a view toward pointing out the interrelationships between duties. Chapter 1 also discusses the observer ladder in terms of your prospective career development and training. The chapter concludes with a look at management and supervision. Chapter 2 of this volume enlarges upon the basic principles of meteorology that you studied in the resident course. This chapter investigates the processes responsible for the production of the weather elements that you observe and report. Subjects under consideration include pressure systems, general circulation, local winds, temperature and moisture, air masses, and frontal weather effects. The last section in Chapter 2 centers its discussion on meteorological table preparation and mathematical calculations. To help you study this portion of Chapter 2, work the example problems and tables given in the text as you read the discussion. Simply reading the given numbers is not always enough; to understand the theory, work the math. In Chapter 3, you will be reintroduced to the subject of weather station equipment, such as cloud height sets, visibility sets, precipitation gages, pressure instruments, temperature-humidity sets, and communications equipment. There is also an in-depth discussion of weather radar.

Volume 2 discusses how surface weather and radar observations are taken and recorded. Volume 2 also discusses station administration and supply. Volume 3 deals with weather plotting and communications; it also includes a brief section on the weather network function. Volume 4 covers upper air observations and tactical stations, on subjects such as pilot balloon, rawinsonde, dropsonde, and rocketsonde observations. Portable and tactical observing stations are also discussed in Volume 4.

Printed and bound in the back of this volume are six foldouts. Whenever you are referring to one of these foldouts, please turn to the back of the volume and open the foldout for reference as you read the text. (Code numbers appearing on figures do not concern you; they serve merely to identify the figure for the preparing agency.)

If you have questions on the accuracy or currency of the text subject matter, or recommendations for its improvement, send them to Tech Tng Cen (TTOC), Chanute AFB, IL 61868.

If you have questions concerning course enrollment, administration, or any of ECIs instructional aids (Your Key to Career Development, Study Reference Guides, Chapter Review Exercises, Volume Review Exercise, and Course Examination), consult your education officer, training officer, or NCO, as appropriate. If he can't answer your questions, send them to ECI, Gunter AFB, AL 36118, preferably on ECI Form 17, Student Request for Assistance.

This volume is valued at 30 hours (10 points).

Material in this volume is technically accurate, adequate, and current as of September 1971.

25251 00 S01 7410

CHANGE SUPPLEMENT

CDC 25251

WEATHER OBSERVER

(AFSC 25251)

Volumes 1, 2, 3, and 4

IMPORTANT: Make the corrections indicated in this change supplement before beginning study of this course. This supplement is printed on one side only to permit "cut and paste" posting of lengthy changes in case you prefer to post these changes in this manner.

CHANGES FOR THE TEXT: VOLUME 1

Page	*Paragraph*	*Line(s)*	*Correction*
iv		7	Change currency date to "April 1974."
15			Label the table at the top of the page to read: "Table 2 Miscellaneous Training Requirements."
53	7-34	3	Insert "by" in front of "vertical."
58	7-57		Add new last sentence: "Discontinue wet-bulb readings at dry-bulb temperature below -35° Fahrenheit."
60	7-63	3	Change "AN TMK 11" to "AN TMQ 11."
77	9-16	11 thru 14	Delete sentences beginning with "The two daily . . ." and "You can see. . . ." and replace with "Take 10 comparison readings at hourly intervals. Date and time each reading in columns 2 and 3."
77	9-19		Delete and replace with new paragraph: "9-19. Make this comparison for 10 consecutive hourly readings and compute the algebriac mean. Referring to the sample AWS Form 85 (fig. 49), notice that the corrections are totaled and then entered in column 11 on the 1747 LST line. Indicate also the first and last numbers of the comparisons used in making up the total correction. Then find the mean correction from these two items and enter the results in column 12. The aneroid barometer may now be used by applying the correction in column 12 until it is redetermined the next day."
77, 80	9-20		Delete and replace with new paragraph: "9-20. Comparisons are made twice a day for the next 5 days at 6-hourly intervals and at the same time each day. Beginning with the first daily

Page	Paragraph	Line(s)	Correction
			comparison, columns 15 and 16, AWS Form 85, will come into use. Column 15 shows the results of applying the mean correction (Col 12) to the aneroid reading (Col 9). After you do this, compare column 15 with column 6 and enter the difference in column 16. When you have 20 consecutive readings and no column 16 entry has exceeded ± .010 inch or ± 0.3 mb limits, you will consider the aneroid reliable. From this point, discontinue the daily comparisons and begin weekly comparisons."
78	Figure 49		Delete and replace with new figure 49.
80	9-21		Delete and replace with new paragraph: "9-21. The weekly comparisons are intended to keep the aneroid correction current. When you begin the routine weekly readings, redetermine the posted correction each week by obtaining the algebraic mean of the last 10 readings (including the two readings from that day). Use this posted correction (Col 12) to apply to the readings of the aneroid instrument. Figure 49 shows this was done on 2 24. This comparison shows an interesting comment. Comparison number 22 was omitted from sums because the correction was +.012, exceeding the limit for one reading. Corrections this large should be verified immediately. This was done on our sample with comparison 22a at 1210, and a difference of .000 prevailed. Turn the completed AWS Form 85 in to your chief observer who keeps it on file until the aneroid is replaced."
88	10-21		Delete and replace with new paragraph 10-21: "10-21. You transmit all other meteorological data such as pilot reports (PIREPs), forecasts (PLATFs), radar weather reports (RAREPs), etc., on the OWS unit. After you have prepared and properly inserted the tape in the transmitters, your tape will not transmit until the proper bulletin is scanned. Suppose, for example, that your RAREP is on tape. In this case you would insert the tape with the proper message format. This allows computer collection of weather data in the continuous polling mode that requires specific message formats."

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Acknowledgment

Grateful acknowledgment is made to Western Union for permission to use the Western Union Model 311 photograph presented in Chapter 3. This photograph was obtained from the *Electronic Printer's Manual*, published 1 July 1968, by Western Union.

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MODIFICATIONS

Chapter 1 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

CHAPTER 2

Meteorology and Mathmatics

YOU, AS A WEATHER observer, are an integral part of the weather team and contribute the most fundamentally important element of the service that weathermen provide. It follows, then, that a basic understanding of the elements of meteorology will better enable you to appreciate the "whys" underlying your job and how your job relates to the duties of the forecaster. If it does nothing else, an understanding of meteorology can acquaint you with the limitations of present-day forecasting and to what degree the forecaster depends upon you. A far more positive reason for a knowledge of meteorological principles is the intangible assistance this knowledge will give you in anticipating the weather conditions you will observe and report.

2. To an observer, a knowledge of meteorology is also necessary in order to instruct or train less experienced observers. For example, under certain circumstances (geographical considerations aside), the "Convective Cloud Height Diagram" in *Federal Meteorological Handbook #1* (FMH 1) is a valid tool for estimating the bases of cumulus clouds. Only a knowledge of meterology will enable you to determine whether the convection causing the cumulus to form is a result of heating (allowing the use of the cloud height diagram) or is associated with a front (in which case the cloud height diagram is not valid). Practical applications of meteorology such as this must become your stock-in-trade as a technician and must ultimately become a part of your overall job knowledge.

3. This chapter is designed to increase your knowledge of meteorology and to cover the areas of mathematics that will aid you in your duties as a weather observer. The first section of the chapter discusses the fundamentals of meteorology involving pressure and wind circulation, temperature and moisture, air masses, and frontal weather effects. Section 2 centers its discussion on the preparation and interpolation of meteorological tables. To begin your study of meteorology, you should first quickly review the structure and composition of the atmosphere.

5. Fundamentals of Meteorology

5-1. The atmosphere consists of a shallow layer of gases that surrounds the earth. As such, it contains gases in varying proportions and includes moisture in the form of water vapor. The composition of the atmosphere is 78 percent nitrogen, 21 percent oxygen, and 1 percent inert gases. By weight, approximately one-half of the atmosphere lies below the 500-mb level (18,289 feet). The layers of the atmosphere in ascending order are: (1) the troposphere, (2) stratosphere, (3) mesosphere, and (4) ionosphere, the lower part of the thermosphere. The boundaries between the layers are nonuniform, and actually are diffuse and difficult to identify because of the unequal distribution of atmospheric pressure and temperature.

5-2. Two important characteristics of the atmosphere to keep in mind are: (1) temperature normally decreases with an increase in altitude, and (2) the amount of water vapor that a given sample of air can hold is a function of the temperature—that is, warm air is better able to hold water vapor than cold air. Though water vapor exists as a small and variable amount of the total atmospheric gases, it is one of the most important gases when it comes to "weather." Water vapor is important not only because it is the raw material for clouds and rain, but also because it serves as one of the regulators of the earth's temperature. Without temperature regulators, our earth would continue to get warmer. Then how is the temperature balance maintained? To answer this question, we must investigate the pressure and wind circulation of our atmosphere.

5-3. **Pressure and Wind Circulation.** All weather phenomena are basically the result of the unequal distribution of solar heat acting upon the earth and its fluid envelope, the atmosphere. The spherical shape of the earth influences the amount of heat received by the earth at the equator, the midlatitudes, and at the poles. Since we know that the net heat loss and gain for the earth and atmosphere as a whole are maintained in a state of balance, there must be a latitudinal transfer of heat. To maintain this balance, the atmosphere constantly undergoes changes to compensate for the unequal heating. This constant change and movement of huge masses of the atmosphere is known as the *general circulation.*

5-4. *General circulation.* The circulation of the air would be very simple if the earth's surface were smooth and uniform and the earth were stationary. Movements within our atmosphere would have to be caused by pressure or density differences from one place to another. Since the earth does rotate, the effects of rotation and coriolis upon the general circulation must be considered. The "three-cell theory" of circulation best describes these effects. This theory divides the Northern and Southern Hemispheres into three latitudinal belts of 30° each. The boundaries of these three cells are the Equator, 30° (north and south), and 60° latitude (north and south). For our purposes, we can confine our discussion to the three cells in the Northern Hemisphere. The rotation of the earth causes the coriolis effect by deflecting a moving particle to the right in the Northern Hemisphere. The flow of air from the middle latitudes (30°–60°) toward the pole would, therefore, be deflected to the right (east) and become a westerly flow, while flow from the pole southward (0°–60°) would become an easterly flow. The circulation is more complex than this initial deflection would imply, but the basic flow pattern can be broken down into three distinct circulation cells as shown in figure 6.

5-5. The first cell is formed by the warm air rising at the Equator and flowing north. As the air moves north, it is deflected to the right by coriolis to become the upper westerlies. While the air moves north, it cools, and by the time it reaches 30° north, a portion of this air is cool enough (dense enough) to descend and form an area or belt of high pressure at 30° north. Remember, only a portion of the air descended. The remainder continues to move northeasterly (because of coriolis) until it reaches the pole. At the pole, the air descends, causing another area of high pressure and then begins to flow southward. Coriolis force is greatest at the poles, and the southward flowing air is deflected greatly to the right to become easterly flow on the surface, while the wind at upper levels continues to be westerly. (The wind at upper altitudes from the Equator to the pole is westerly.) At 30° north, the sinking cool air divides to flow both north and south at the surface. The air flowing southward, deflected by coriolis, becomes the northeast trade winds between the Equator and 30° north. The air flowing northward of 30° is also deflected by coriolis, and being closer to the pole, the deflection is greater. Therefore, the air aloft and on the surface is westerly.

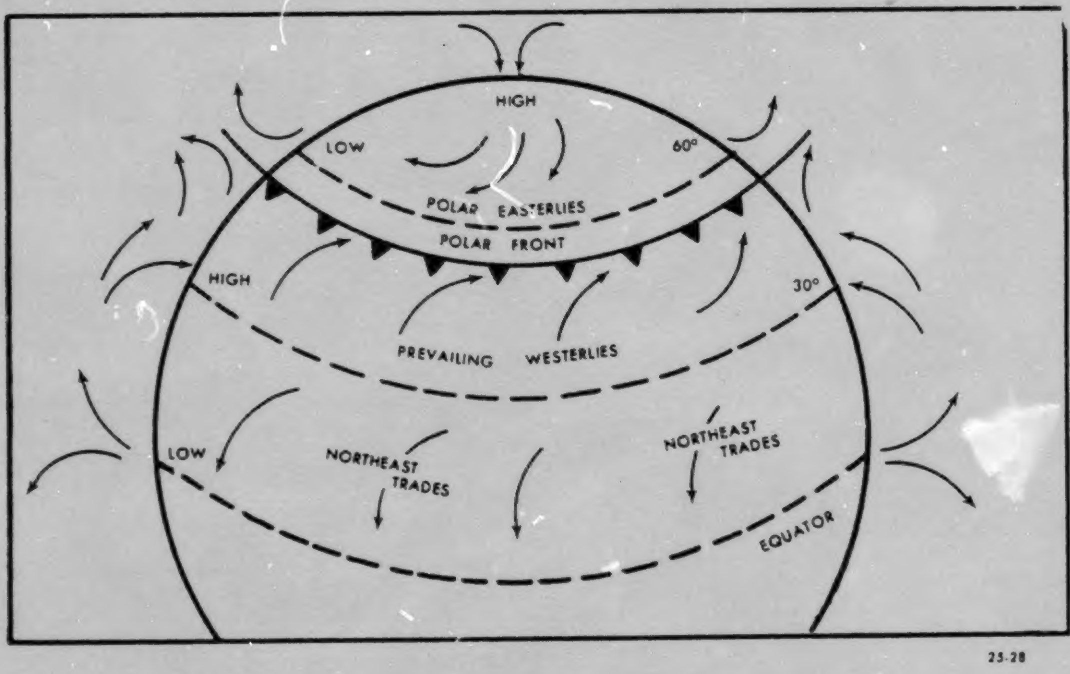

Figure 6. Three-cell theory of circulation.

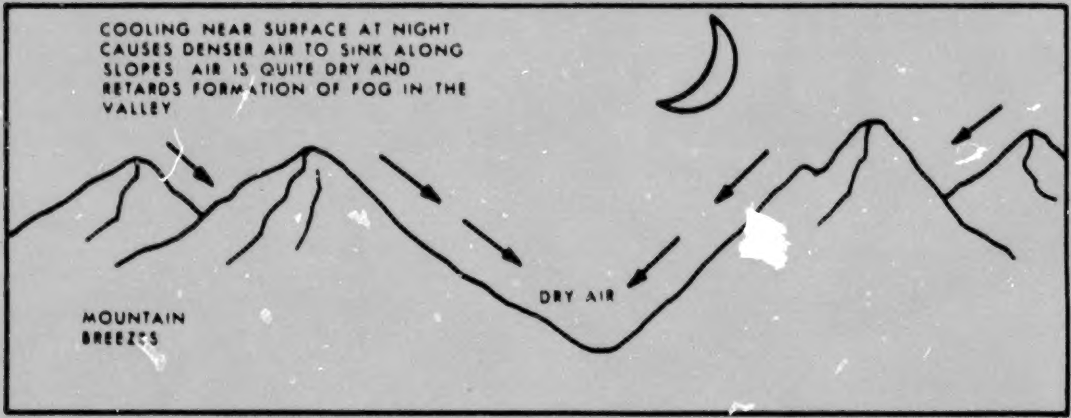
COOLING NEAR SURFACE AT NIGHT CAUSES DENSER AIR TO SINK ALONG SLOPES. AIR IS QUITE DRY AND RETARDS FORMATION OF FOG IN THE VALLEY
DRY AIR
MOUNTAIN BREEZES
25 46

Figure 7. The mountain breeze.

5-6. We have now briefly discussed the general circulation and its development. The three-cell theory of circulation is coincident with the development of *semipermanent pressure systems*. These pressure systems are developed through the cellular circulation and are found in nearly the same regions at all times of the year, undergoing seasonal variations in position and intensity.

5-7. *Semipermanent pressure systems.* If land and water masses were uniformly distributed upon the earth's surface, these pressure systems would be less subject to change and could then be more justifiably called "permanent." The unequal distribution of land and water masses and their differing heat absorbing and radiating properties, however, cause a seasonal variation in the position and intensity of these systems. In the Northern Hemisphere there are three semipermanent high cells and two semipermanent low cells. The centers of these systems vary geographically from summer to winter.

5-8. The names of the high-pressure cells are the Bermuda High (Atlantic Ocean), Siberian High (Central Russia), and the Pacific High (which covers most of the central Pacific Ocean). The low-pressure cells are the Aleutian Low (Northern Pacific) and the Icelandic Low (Northern Atlantic). The high-pressure systems (except the Siberian High) are more dominant in the summer, and the low-pressure systems dominate in the

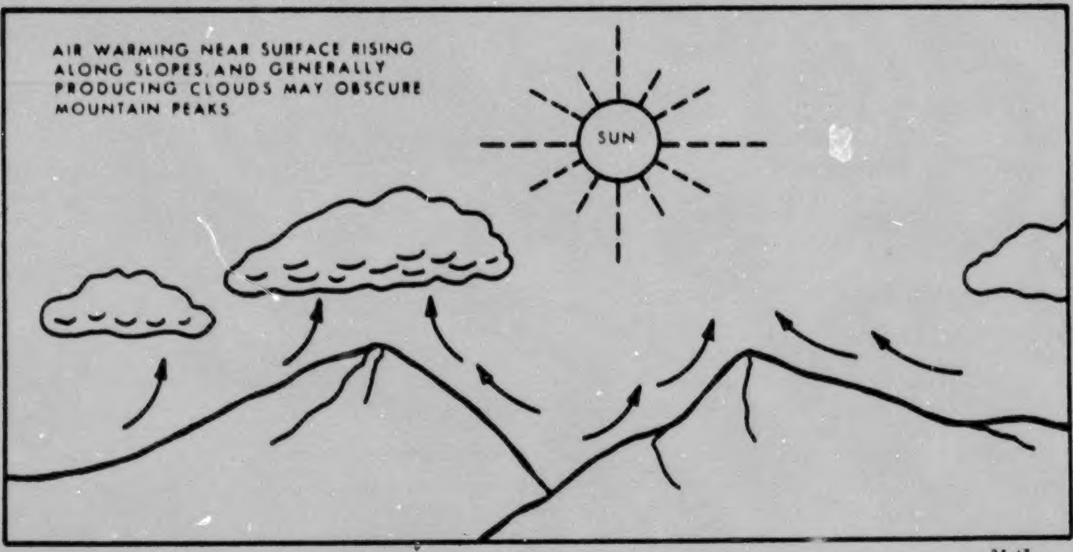
AIR WARMING NEAR SURFACE RISING ALONG SLOPES AND GENERALLY PRODUCING CLOUDS MAY OBSCURE MOUNTAIN PEAKS
SUN
25 47

Figure 8. The valley breeze.

winter. The interaction of these large-scale semipermanent systems causes the formation of lesser high- and low-pressure systems that move with the prevailing windflow as influenced by the general circulation.

5-9. *Migratory pressure systems.* Since the migratory systems generally move along in accordance with upper level flow, they account for a far greater amount of heat exchange than do the semipermanent systems. These moving systems bring the bad and good weather that is usually associated with low-pressure and high-pressure areas respectively. A later discussion explains the weather patterns associated with these migratory pressure systems. We know that the physical characteristics of the earth do not affect the upper level winds, but they do have a definite effect on the surface and lower level winds. The rough surface and land-water temperature differences produce local winds that, in many cases, mask the general circulation winds.

5-10. *Local winds.* The local winds consist of such winds and patterns as land and sea breezes, mountain and valley breezes, and the forced-circulation type winds. These latter winds occasionally have local names such as Santa Ana, bora, chi-

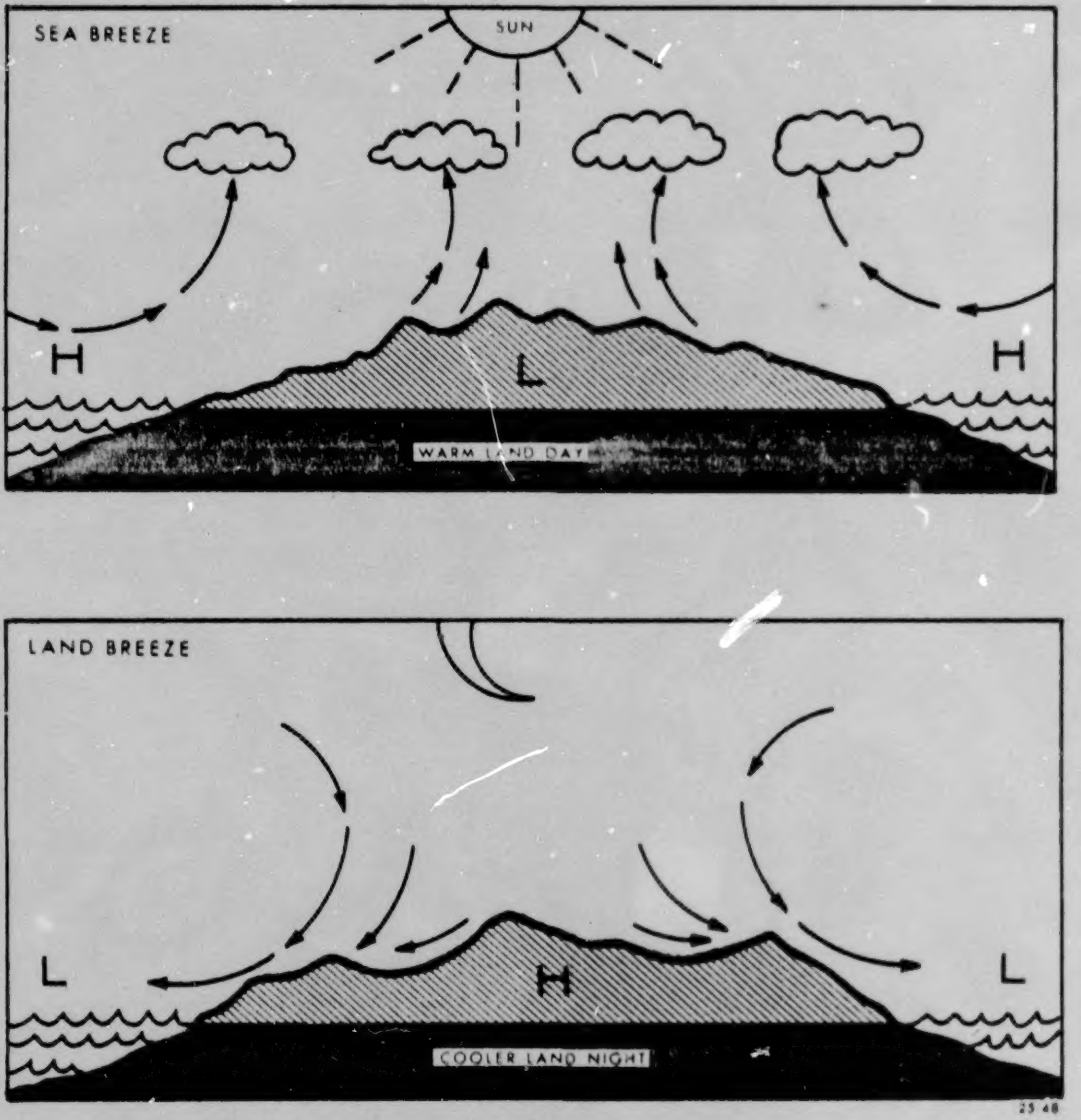

Figure 9. Land and sea breezes.

nook, foehn, and others. Most local winds, while their names are numerous, fall into four categories. They are local-cooling, local-heating, adjacent local-heating and cooling, and the forced-circulations. Each of these types may be illustrated by a typical example. In figure 7, the local-cooling type wind is the mountain breeze. At night, because of radiational cooling, the air in contact with the mountain slopes becomes colder and denser than the surrounding air and sinks along the slopes. Even when the mountain breeze is well developed, it rarely exceeds 12 to 15 knots. Figure 8 shows the local-heating type wind called the valley breeze. Sunlit mountain slopes and the air next to the slopes are usually warmer than the surrounding air during the day. The air in contact with the slopes becomes lighter than the surrounding air and rises up the slopes. This is called a valley breeze because it flows up and out of the valley. The valley breeze is usually stronger and better developed than the mountain breeze, and reaches its maximum speed at midafternoon.

5-11. The land and sea breezes illustrate the adjacent heating and cooling type wind, as shown in figure 9. Since land masses absorb and radiate heat at a rate three times more rapidly than water masses, the land is warmer than the water during the day and colder at night. Along a coast or shoreline, "sea breezes" (coming from the sea) would be expected in the afternoon. Increased temperature of the land causes hot air to rise over it. Then the cooler air over the water flows landward to take its place. At night, the system reverses itself to produce "land breezes." The now cooler land produces a cool breeze to flow out over the warmer water. The land breeze is best developed just before dawn. This entire pattern depends on the fact that water warms and cools much slower than land. The sea breezes reach maximum velocity between 1400 and 1600 local time since they are usually stronger than land breezes, they penetrate inland as far as 25 to 30 miles. Both the land and sea breezes are shallow in depth.

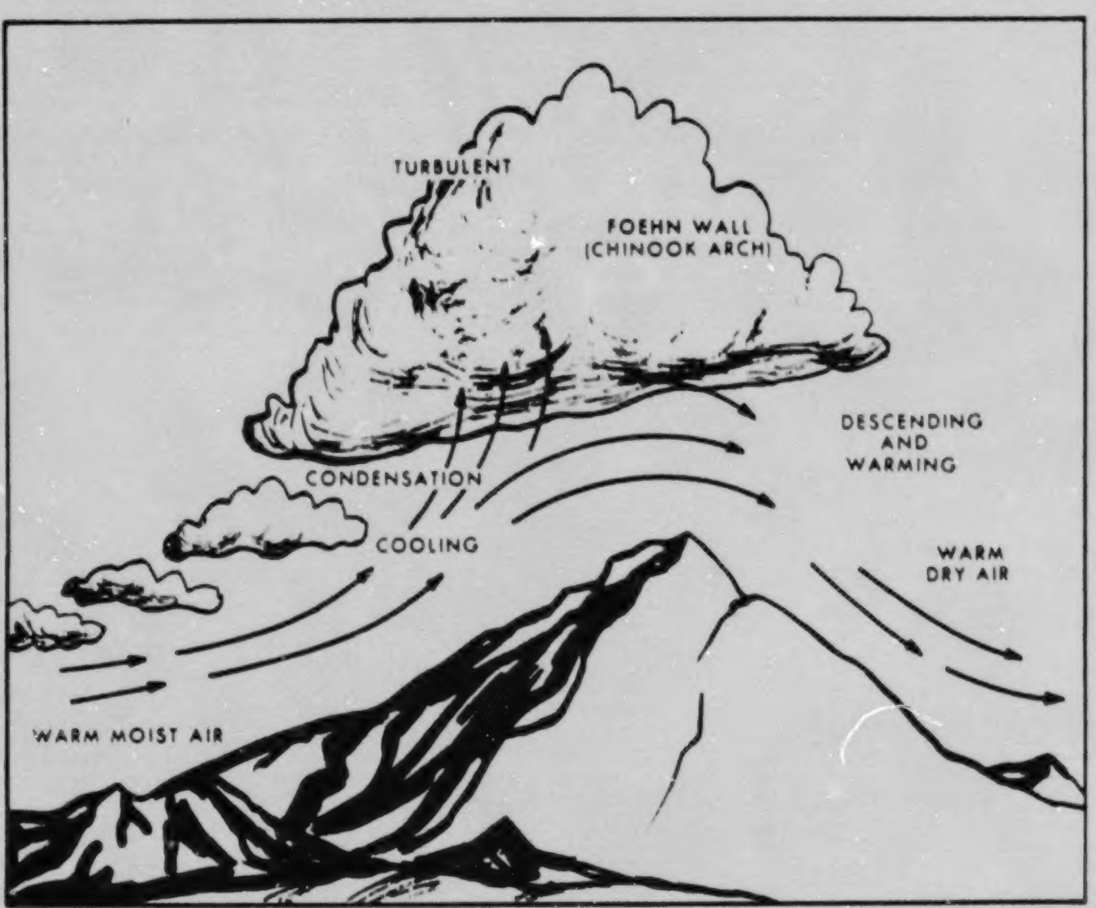

Figure 10. The chinook wind.

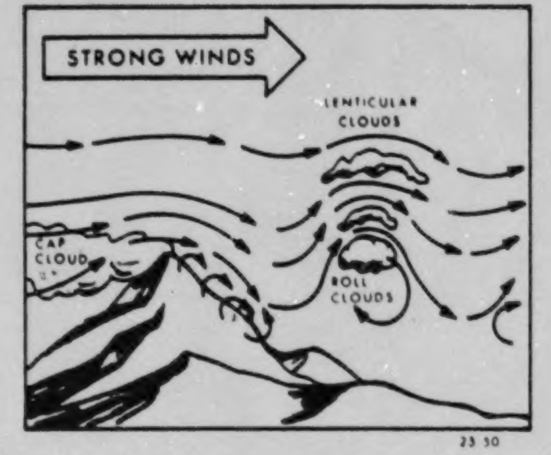

Figure 11. Mountain wave.

5-12. Forced-circulation winds are those intensified by terrain, usually mountain ranges. Two forced-circulation winds are the "mistral" and the "bora." Both are cold fall (downslope) winds that remain colder than the air they replace in the lowlands. Extremely strong and gusty, they often cause considerable damage. The "mistral" pours down from the highlands and intensifies as it funnels through the valleys. It is most violent in winter and spring, usually lasting for several days, sometimes with short lulls. These winds are found wherever there are highlands that tend to trap cold air, but derive their name from such winds that develop in southern France. Speeds often exceed 60 mph and reach 80 mph in the lower Rhone Valley of France. The "bora" is the local name of the fall wind along the coast of Yugoslavia. Cold air crosses the mountains and pours down onto the waters of the Adriatic Sea. It is very strong and sometimes has squalls that may reach 100 mph or more. When the bora occurs in conjunction with cyclonic (counterclockwise) circulation, there is considerable cloudiness and rain over the lowlands; but when the flow is anticyclonic (clockwise), the skies are cloud free.

5-13. The "foehn" wind, called the "chinook" in North America, is a warm, dry, downslope wind. Figure 10 illustrates the chinook wind. The air rising on the windward side of the mountain cools and loses its moisture content through condensation. Continuing over the crest of the mountains, the dry air descends the leeward slopes. This downslope motion causes compression and subsequent heating of the air; thus, a dry, warm wind blows down the mountain. A chinook wind may raise the temperature by as much as 30° Fahrenheit in just a few minutes at stations located at the base of the mountains. On the leeward side of the mountains, the air is clear and dry. On the windward side, clouds build up and rain occurs in what is called the "foehn wall" or "chinook arch."

5-14. A special type of foehn wind develops when very strong flow occurs perpendicular to the mountain range, and when the windspeed increases rapidly with altitude. This condition also causes the formation of the mountain wave condition. Figure 11 shows the air flow and associated clouds with a mountain wave. The air flows fairly smooth with a lifting component as it moves up the windward side and gradually increases, reaching a maximum near the peak of the mountain. On passing the peak, the flow breaks down into a complicated pattern with downdrafts predominating. Continuing downwind, 5 to 10 miles from the peak, the airflow begins to ascend as part of a definite wave pattern. Additional waves, generally less intense than the primary wave, may form further downwind.

5-15. Characteristic cloud types, peculiar to wave action, provide the best means of visual identification. Although the lenticular clouds in the illustration are depicted as being smooth in appearance, they may be quite ragged when the airflow at their level is turbulent. These clouds may form singularly or in layers at heights usually above 20,000 feet. The "roll" cloud forms at a lower level, generally about the height of the mountain ridge. While clouds are generally present, it is possible for wave action to take place when the air is too dry to form clouds.

5-16. Thus far in our discussion, primary emphasis has been toward the pressure and wind circulations of the atmosphere. As we mentioned earlier, before there can be any movement of the atmosphere, there must be differences of pressure or density. These differences are brought about by temperature variations (one of the important basic causes of weather).

5-17. **Temperature and Moisture.** Every phenomenon occurring in the atmosphere that we call weather is the result of differential absorption and reradiation of solar energy, as well as the availability of moisture. Heat and temperature are closely related terms, but heat is an energy quantity, while temperature is merely a measure of heat. The main source of heat in the atmosphere is the insolation from the sun. Moisture is added to the atmosphere by evaporation from the surface of the earth. Next, review the methods by which heat is transferred and the processes that lead to precipitation and the subsequent return of moisture.

5-18. *Heat transfer.* The earth receives its heat from the sun, then reradiates it into the atmosphere and space. This process preserves the heat balance of the earth and its atmosphere. There are four basic methods of heat transfer: radiation, conduction, advection, and convection.

5-19. The earth receives heat from the sun in the form of *short-wave radiation*. The gases in the atmosphere, including water vapor, are virtually transparent to short-wave radiation. Although the reflectivity off the cloud tops is such that a considerable amount of solar radiation is prevented from reaching the earth's surface, a substantial amount passes through the clouds. The short-wave radiation is absorbed by the earth during the day and then reradiated into the atmosphere in the form of *long-wave radiation* at night. The lower layers of the atmosphere absorb most of the earth's radiation, leaving less to be absorbed at higher altitudes. Therefore, absorption of the earth's long-wave radiation by the atmosphere traps (for a time) some energy that would otherwise be quickly lost to space. As the water vapor and clouds absorb the long-wave radiation, part of it is reradiated back to earth. This absorption and reradiation by water vapor and clouds establishes a "greenhouse effect" (discussed following the other methods of heat transfer). As mentioned earlier, the air in our atmosphere is heated primarily from its contact with the warm surfaces of the earth.

5-20. Heat transfer by *conduction* requires direct contact. On a sunny day the earth's surface is heated by absorbing radiation. After the earth's temperature becomes higher than that of the surrounding air, the air in contact with the earth is warmed by conduction. At night the process is reversed. The earth is cooled rapidly by terrestrial radiation, and the air in immediate contact with the ground is cooled as the air gives off some of its heat by conduction to the cooler earth. Remember that air is a poor conductor of heat. For this reason the temperature of the air lags behind that of the earth and changes less. The poor conduction of the air and its slow loss of heat explains why frost can occur on the ground when the free air temperature at standard observation height is considerably above freezing.

5-21. During heat conduction, the conducting mass does not move. Advection and convection require mass movement to transfer heat. Except for the direction of movement, advection and convection are essentially alike. *Advection* refers to the horizontal transport of heat, such as by wind or water. The Gulf Stream provides a good example of advection bringing warm Caribbean water to the cold North Atlantic area. *Convection*, on the other hand, refers to the vertical transport of heat. A forest fire, for example, sends great volumes of hot air aloft, thus warming the atmosphere to some degree.

5-22. Convection is of considerable significance in the transfer of heat. As the air is heated near the earth's surface, it becomes less dense and rises. While rising, the air cools to the point where the water vapor condenses into visible droplets (a cloud formation). Since water vapor plays such an important part in maintaining our heat balance, we should not consider the previously mentioned "greenhouse effect."

5-23. *Greenhouse effect*. Water vapor and clouds absorb radiation on a selective basis. They absorb a greater amount of long-wave radiation than short-wave radiation. After some experience in weather observing, you will find that an overcast cloud layer has the effect of minimizing the maximum temperature during the day and moderating the minimum temperature during the night. The reason for this is that the clouds and water vapor act in much the same way as the glass in a greenhouse. Part of the long-wave radiation emitted by the earth is absorbed, reradiated, and reflected by the clouds. The earth absorbs this radiation and reradiates it again, the process continues. The result of the greenhouse affect is a higher average temperature on cloudy nights, and hence, a smaller probability of fog. The ability of water vapor to absorb and emit long-wave radiation is of primary importance in maintaining the earth's temperature balance. But if these facts are valid, how does water vapor get into the atmosphere?

5-24. *Evaporation*. Water vapor is acquired by the atmosphere through evaporation over lakes, rivers, oceans, and even snow. The evaporation process is the physical act of changing the state of water from a liquid to a gas. This change of state requires a large amount of heat. Just as the evaporation of perspiration cools the human body, so does the evaporation of water into the air cool the surrounding area. This might be noted by a change in the air temperature in the summer as you near a body of water, such as a large river or lake. Evaporation, then, could be considered a cooling process.

5-25. Obviously, the air cannot continue to accept water vapor without being changed in some way. The amount of evaporation that will take place depends upon how much water vapor the air can hold which is, in turn, directly dependent upon the air temperature. When the air contains all of the water vapor it is capable of holding, it is said to be *saturated* (100 percent humidity). Saturation of the air occurs by two basic methods: (1) the evaporation process continues until the air, at a constant temperature, will hold no more water vapor or (2) the temperature is decreased, and the capacity decreases accordingly until the capacity will not equal the actual amount of water vapor in the air. To simplify an explanation of these methods, we can say that air may be saturated by the addition of water vapor or by cooling it. Remember that the process of evaporation is a cooling process; that is, heat is drawn from the atmosphere. When the reverse occurs (condensation), this heat is returned to the atmosphere.

5-26. *Condensation.* Once the air reaches saturation, any further addition of moisture causes this excess water vapor to condense into visible moisture. This process (called condensation) accounts for the removal of most of the water vapor in the atmosphere. The most common forms of visible moisture are clouds and fog. Although the addition of water vapor to the air can produce saturation and condensation, saturation and condensation are reached most frequently by cooling the air. This cooling may occur from the air passing over a colder surface (advection); by the air being lifted, such as being forced up a mountain (adiabatic cooling); or by the ground beneath the air cooling at night by radiation and thereby cooling the lower layers of the air by conduction. This latter situation most frequently produces fog rather than clouds. With an increase in the wind to 15 knots or more, this fog may rise and become a layer of stratus clouds. While condensation accounts for most of the release of water vapor from the air, there are conditions where condensation will not occur.

5-27. *Sublimation.* With temperatures below freezing, the water vapor may change directly from a gas to a solid, producing frost, snow, or ice fog. This process (called sublimation) works in both directions. Water vapor may get into the air directly from frost or snow, as in the case where the snow just seems to disappear without melting. Water vapor may also be removed from the air by changing to frost or snow. Cirrus clouds are formed by the sublimation process when water vapor at high altitudes changes to ice crystals.

5-28. Now that we have discussed how the earth's temperature and mositure balance are maintained, we should investigate the influence that temperature and moisture have on the development and modification of airmasses.

5-29. **Airmasses.** An airmass is a large body of air having about the same horizontal temperature and moisture properties. Frequently, in certain geographical areas, in airmass will have little or no tendency to flow toward another area. Such an airmass is, in effect, stagnant. If this period of stagnation extends over long periods of time, the airmass acquires the temperature and moisture properties of the underlying surface. These properties depend upon the physical and geographical nature of the underlying surface. By the time such a change has been completed, an extensive portion of the airmass has become the same throughout, and its properties are more or less uniform at each level.

5-30. The regions in which airmasses are formed are called source regions. The source region is the essential factor determining the individual properties of the airmass. The depth and properties that an airmass assumes depend on the length of time it remains over the source region. Other factors that determine the eventual characteristics of an airmass are: (1) the characteristics of the surface over which the airmass travels after leaving the source region, and (2) the length of time that the airmass has been away from the source region.

5-31. To fulfill the requirements for a good source region, an area must have a fairly uniform surface, uniform temperatures, and preferably an area of high pressure where the air has a tendency to stagnate. Many regions of the earth do not fulfill these requirements. For example, most midlatitude regions are too variable with respect to temperature, because of the almost continuous intrusion of airmasses from the north and south. On the other hand, large snow or ice-covered polar regions, tropical oceans, and large desert areas adequately fulfill source region requirements.

5-32. *Classification and characteristics.* An airmass forming over the polar ice cap would have different properties from one forming over the tropics. To indicate this difference, each airmass is labeled according to its source region—"T" (tropical), "A" (arctic), "P" (polar), and "E" (equatorial). They can be further classified according to moisture content; "c" for continental (dry) and "m" for maritime (moist). When the airmass leaves its source region and moves over a surface that has a different temperature, the airmass is then classified as either warm or cold, relative to the surface beneath it. That is, if the airmass is warmer than the underlying surface, it is characterized as warm. A cold airmass, of course, is one whose temperature is colder than the underlying surface.

5-33. The letter designator for a warm airmass is "w" and for a cold airmass, "k." Another letter is used to indicate whether the airmass is stable(s) or unstable(u). Just as the initial classification is based upon properties acquired in the source region, later classification depends upon the degree of change that the airmass undergoes as it moves from one region to another. The amount of change depends upon the type of surface, its temperature relationship with the airmass, the trajectory of the airmass, and the time elapsed since the airmass left its source region. Airmass properties are encoded in a specific order. For example, *cPku* (as designated on charts and diagrams) is a dry (c), cold (k), unstable (u), airmass from a polar (P) source region. Note that the little letters are the airmass properties and that the capital letter is for the source region.

5-34. The weather conditions within an airmass depend upon the temperature and moisture properties acquired in the source region and the extent to which they become modified as they move out of the source region. You should note whether the airmass is cold, warm, moist, etc. When we speak of an airmass, just exactly what do we mean? Specifically, we mean a large body of air between two frontal systems. For the most part, this is a large high-pressure system. The low-pressure system and front is merely an interaction between the two airmasses. The circulation around a low is cyclonic (or counterclockwise) and anticyclonic around a high (clockwise). It is from this terminology that we get the names "cyclones" (lows) and "anticyclones" (highs). Unstable conditions and poor weather usually exist with cyclones; whereas, stable conditions and good weather usually prevail with anticyclones. Low-level subsidence inversions (an increase in temperature with height) generally occur in connection with cold anticyclones. When this type inversion occurs over an industrial area, it suppresses vertical development in the lower layers and traps dust, smoke, and haze particles, which markedly reduce the surface visibility.

5-35. In the resident course you learned the typical weather conditions associated with the major airmasses and how they might affect the weather at some particular location. Now it is part of your job to be familiar with (1) the airmasses that predominate at your station, (2) the modifying influences these airmasses undergo in traveling to your station, (3) the weather to expect from them, and (4) their future movements.

5-36. The Terminal Forecast Reference file for your station contains discussions of the various airmasses that affect your station. These discussions are concerned with the particular recurring synoptic situations and their associated weather patterns. By reviewing the file periodically, you should be able to classify the airmasses that move into your area and therefore be prepared to determine the general weather conditions associated with each type. Some of the effects that movement will have on an airmass, and the factors that may change the characteristics of an airmass will now be discussed.

5-37. *Airmass modification.* The modification of weather conditions within an airmass depends upon the changes in temperature, moisture, and stability. The trajectory of the airmass influences the modification of these properties. Most often, changes in temperature, moisture, and stability occur simultaneously, but not necessarily of the same degree. These changes depend upon the physical nature of the underlying surface. As the airmass moves from its source region, it will slowly acquire the temperature and moisture characteristics of the new areas over which it passes. A cP airmass, for example, moving over a large body of water, picks up moisture from evaporation, and is thus modified to mP. Also an mP airmass moving inland over mountains is modified by losing its moisture because of adiabatic cooling and becomes a cP airmass.

5-38. As the airmass moves, the thermal symbol must change in relation to the surface over which it passes. The thermal symbol is relative only to the surface over which it is passing. Heating from below develops an unstable temperature lapse rate because the air at the higher levels remains relatively cool in comparison with the lower levels. An unstable temperature lapse rate is associated with turbulence and convection; and, if clouds formed, they would be of the cumulus type. Visibility would be good because turbulent mixing disperses the smoke and haze, and prevents the formation of fog. When an airmass is cooled from below, it has a stable lapse rate and the clouds are a stratus type. Visibility could be restricted by fog, smoke, or haze.

5-39. So far we have been concerned mainly with getting acquainted with how airmasses come into being, their different types, and modifications they undergo as they move over the earth's surface. Now, before discussing frontal weather effects we briefly review some of the more important points concerning airmasses and their associated weather.

5-40. Some of the points to keep in mind are:

a. The advection of cold air over a warmer surface gradually increases the temperature of the cold air and makes it unstable.

b. The relative humidity of air increases as the air cools. If marked cooling resulting from lifting occurs, the air may become saturated; clouds and precipitation are the usual result.

c. Turbulence, vertical air currents, cumuliform clouds, showery precipitation, and good visibility (except in showers) are usually associated with unstable air.

d. Ascending air currents (convection) are produced by the heat the air receives while it is in contact with a hot surface (conduction), by air being forced over mountains (orographic lifting), or by warm air being forced over colder air.

e. The advection of warm air over a colder surface decreases the temperature of the air and makes it stable.

f. Smooth flying weather, stratiform clouds, and poor surface visibilities are usually associated with stable air.

g. The relative humidity of air decreases as the air is heated. For this reason, clouds generally dissipate in descending air currents because the air is heated by its descent.

h. Airmasses acquire water vapor by evaporation from underlying water masses.

i. The water vapor content of an airmass is reduced by precipitation.

j. Mountains, valleys, and water masses modify the temperature and humidity of the airmass over a given locality.

5-41. The weather associated with the different types of airmasses is the predominate weather that you will observe at your station. Frontal weather is more spectacular and quick-changing than airmass weather and for this reason requires close investigation into the associated weather patterns of the different frontal types.

5-42. **Frontal Weather Effects.** The weather associated with fronts and frontal movement is called frontal weather. It is more complex and variable than airmass weather. The type or intensity of frontal weather is determined largely by such factors as the slope of the front, the water vapor content and stability of the airmasses, the speed of the frontal movement, and the relative motion of the airmasses at the front. Because of the variability of these factors, frontal weather may range from a minor wind shift with no clouds or other visible weather activity to severe thunderstorms accompanied by low clouds, poor visibility, hail, icing, and severe turbulence. In addition, the weather associated with one section of a front is frequently quite different from that in other sections of the same front. The reason for this is that the boundary between two different airmasses is not a sharp wall. Instead, there is a zone of transition (referred to as a zone of discontinuity) which is often many miles wide. This zone is customarily called the frontal surface, or merely a front.

5-43. Since the airmasses separated by a front have different temperature and water vapor characteristics, they also have different densities. When airmasses with different densities adjoin, the denser air slides (wedges) under the less dense air. Conversely, we find that the less dense warm air slides up over the denser cold air. As a result, the frontal surface is sloping. The steepness of the slope is measured as the angle between the earth's surface and the frontal surface.

5-44. Discontinuities in airmass properties and characteristics, such as temperature, water vapor content, wind, cloud types, and pressure changes, are used to locate and identify fronts and to trace their movements. One of the most easily recognized discontinuities across a front is temperature. At the earth's surface the passage of a front is usually characterized by a noticeable change in temperature. The rate and amount of the change are partial indications of the intensity of the front. Strong fronts are accompanied by abrupt and sizeable temperature changes, while weak or diffuse fronts are characterized by gradual or minor changes in temperature.

5-45. Near the earth's surface, the discontinuity of wind across a front is primarily a matter of a change in direction. Windspeed is often very much the same on both sides of a front. In many cases there may be a change in windspeed across a front, although the windspeed can increase or decrease after the frontal passage. Although there are different types of fronts, the frontal discontinuities are common to all of them. These next few paragraphs discuss each type of front and its associated weather phenomena.

5-46. *Cold fronts.* A cold front is a front whose motion is such that cold air displaces warm air at the surface. Cold fronts usually move faster and have a steeper slope than warm fronts. The cold fronts that move very rapidly have very steep slopes in the lower levels and narrow bands of clouds that are predominantly just ahead of the front. The slower moving cold fronts have less steep slopes, and their cloud systems may extend far to the rear of the surface position of the fronts. Figure 12 shows the differences in frontal slope and the type and extent of weather with the fast and slow-moving cold fronts. The weather and clouds associated with the slow-moving cold front may extend for hundreds of miles behind the surface front. After passage of the slow-moving cold front, you should expect to have ceilings and visibilities that improve very slowly. By the same token, with the passage of a fast-moving cold front, the visibility and ceilings improve rapidly.

5-47. When the warm air ahead of a cold front is moist and stable, the clouds are predominantly stratiform (nimbostratus, altostratus, cirrostratus) with moderate precipitation (slow-moving cold front). However, when the warm air is moist and unstable (or has a tendency to be unstable), the clouds are predominantly cumuliform, and precipitation is in the form of moderate or heavy showers (fast-moving cold front). A line of thunderstorms frequently develops along a fast-moving cold front that is displacing warm, moist, unstable air. Sometimes, under these conditions, a line of strong convective activity is projected between 50 and 200 miles ahead of the front and roughly parallel to it. If this develops into a line of thunderstorms, it is called a squall or instability line. On the other hand, when the warm air is very dry, little or no cloudiness is associated with a cold front.

5-48. When the cold air behind the front is moist and stable, a deck of stratus clouds and/or fog may persist for some time after the frontal passage. Similarly, when the cold air is moist and unstable, cumulus clouds and showers may occur for some time after the frontal passage. When the cold airmass is very dry, clouds are generally not found in the cold air.

5-49. At the surface, a cold frontal passage is characterized by a temperature and dewpoint decrease, a wind shift, and, on occasion, gusty winds. The weather associated with cold fronts is more

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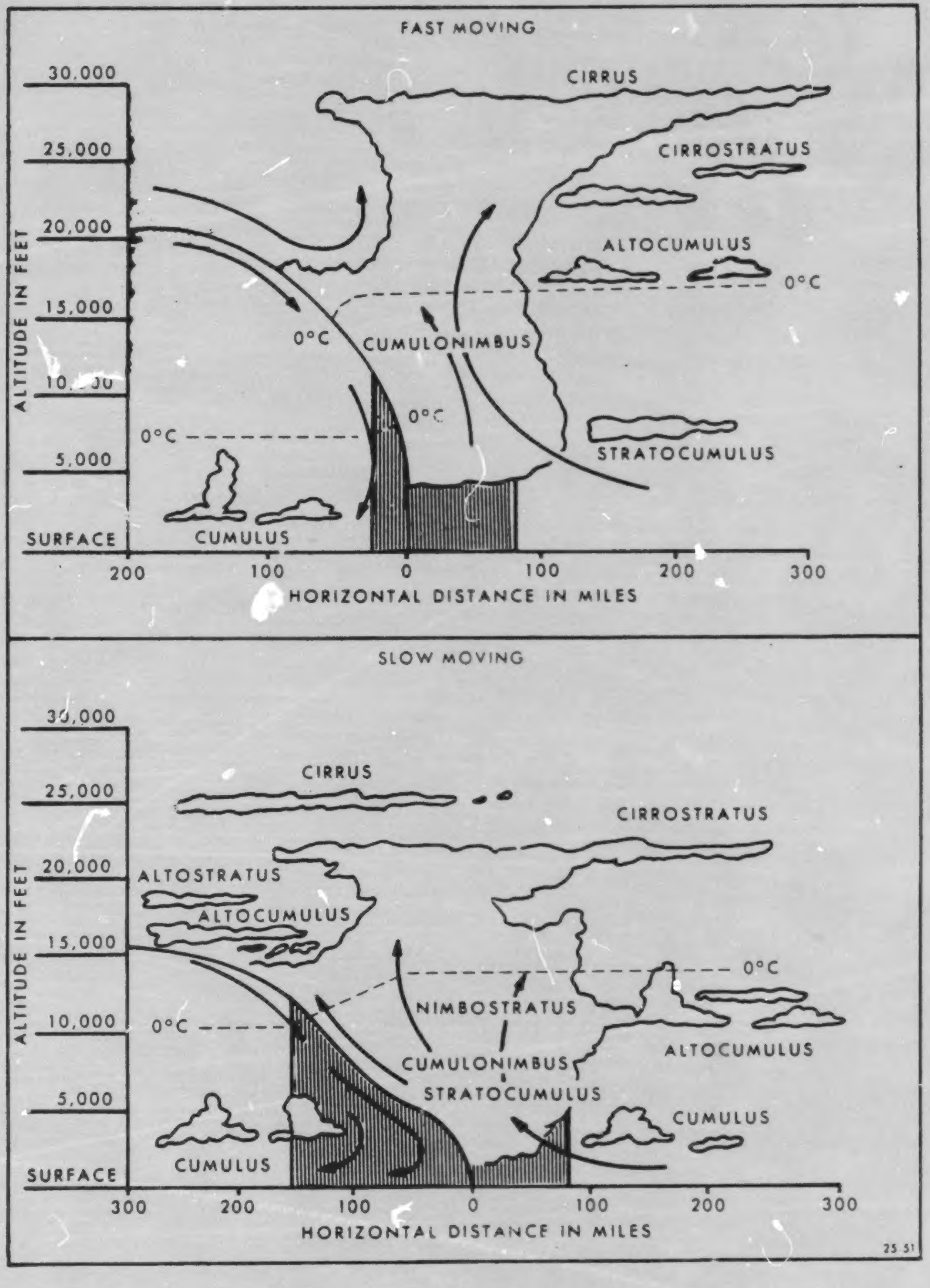

FAST MOVING
30,000
25,000
20,000
15,000
10,000
5,000
SURFACE
ALTITUDE IN FEET
CIRRUS
CIRROSTRATUS
ALTOCUMULUS
0°C
0°C
CUMULONIMBUS
0°C
0°C
STRATOCUMULUS
CUMULUS
200
100
0
100
200
300
HORIZONTAL DISTANCE IN MILES
SLOW MOVING
30,000
25,000
20,000
15,000
10,000
5,000
SURFACE
ALTITUDE IN FEET
CIRRUS
CIRROSTRATUS
ALTOSTRATUS
ALTOCUMULUS
0°C
0°C
NIMBOSTRATUS
CUMULONIMBUS
STRATOCUMULUS
ALTOCUMULUS
CUMULUS
CUMULUS
300
200
100
0
100
200
300
HORIZONTAL DISTANCE IN MILES
25.51

Figure 12. Fast and slow moving cold fronts.

concentrated (in a narrower band) than that associated with warm fronts This often presents more serious flying hazards than those associated with warm fronts.

5-50. *Warm fronts.* A warm front differs from a cold front in that the associated weather pattern is more extensive with the warm front. The clouds are more stratified, and the precipitation is of a continuous nature. As mentioned earlier, the slope of a front is usually a good indicator of the type of weather that may occur with a particular front. The shallow slope of the warm front causes the warm air to gradually overrun the cold air. The more gradual the overruning, the greater the stability of the airmass being forced aloft. Figure 13 is a schematic diagram of the warm front and its associated weather that occur in unstable and stable air.

5-51. In figure 13, notice that the associated clouds are predominantly stratiform and appear in the following sequence with the approach of a warm front: cirrus, cirrostratus, altostratus, and nimbostratus. The only difference in this sequence is when the air is unstable. Then there can be cumulonimbus clouds imbedded within the stratified cloud system and produce showers instead of continuous precipitation.

5-52. *Occluded fronts.* The examples we have looked at and discussed, involved the passage of both a cold front and a warm front. However, there are other possibilities of frontal configurations. These other configurations are variations of the cold and warm frontal structures, and include what we call occluded fronts.

5-53. If the air behind the cold front is colder than the air ahead of the warm front, the occlusion is a *cold front occlusion.* In this case, the advancing cold front remains on the surface and forces the warm front and warm air aloft. As the process continues, the surface warm front becomes an *upper* warm front. This type occlusion occurs in the central and eastern parts of the United States. Figure 14 is a cross section of a cold front occlusion depicting the typical weather and associated cloud patterns.

5-54. In the *warm front occlusion* the cold air ahead of the warm front is colder than the air be-

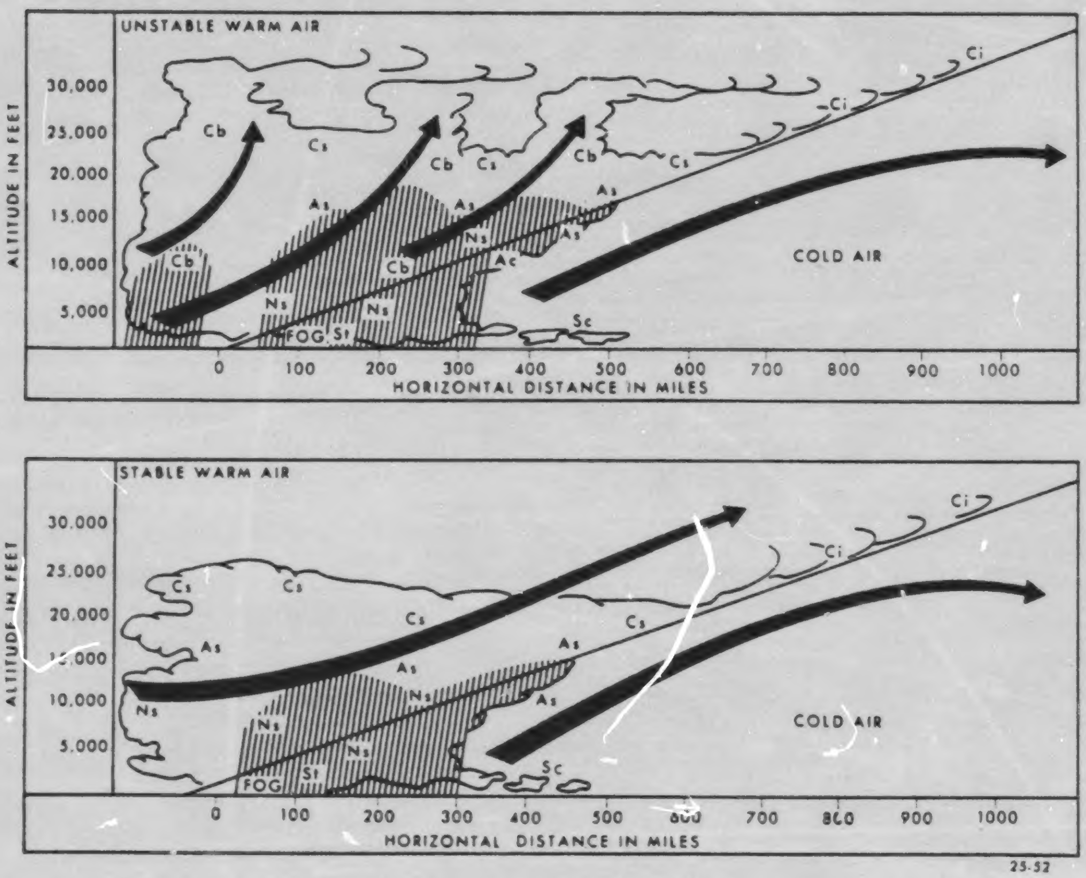
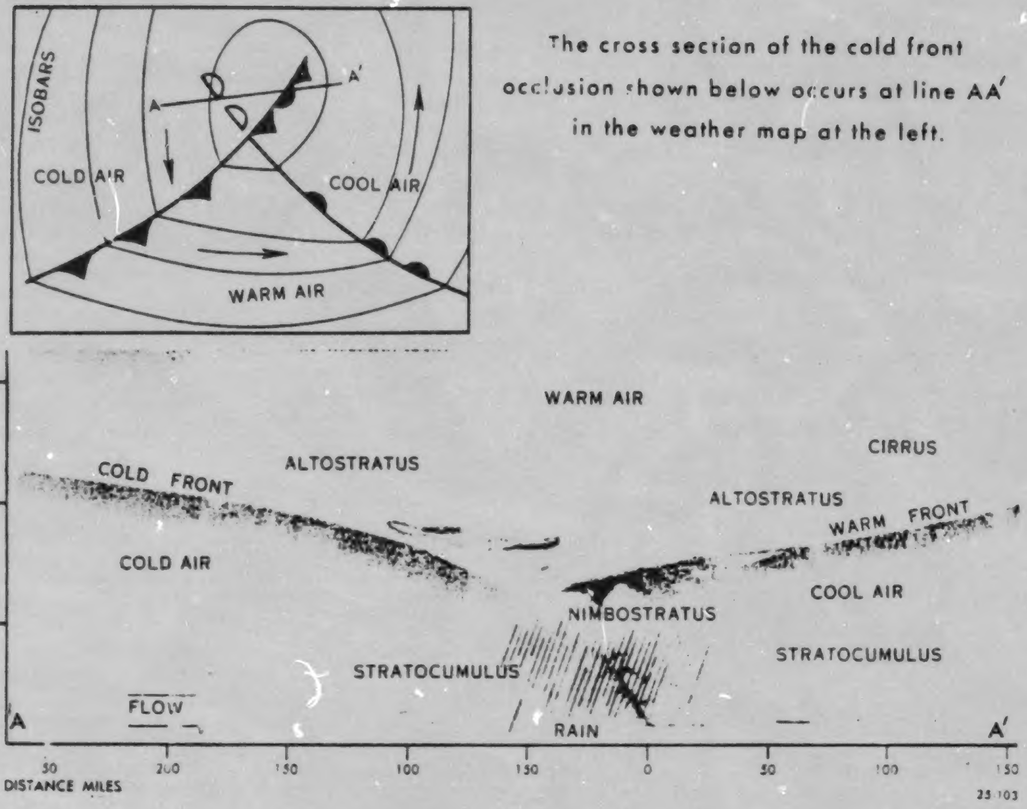

UNSTABLE WARM AIR
ALTITUDE IN FEET
30,000
25,000
20,000
15,000
10,000
5,000
Cb
Cs
Cb
Cs
Cb
Cs
Ci
Ci
As
As
As
Ns
Cb
Cb
Ns
Ns
Ac
As
FOG
St
Sc
COLD AIR
0
100
200
300
400
500
600
700
800
900
1000
HORIZONTAL DISTANCE IN MILES
STABLE WARM AIR
ALTITUDE IN FEET
30,000
25,000
20,000
15,000
10,000
5,000
Cs
Cs
Cs
Cs
Ci
Ci
As
As
As
As
Ns
Ns
Ns
Ns
FOG
St
Sc
COLD AIR
0
100
200
300
400
500
600
700
800
900
1000
HORIZONTAL DISTANCE IN MILES
25-52

Figure 13 Stable and unstable warm fronts.



The cross section of the cold front occlusion shown below occurs at line AA' in the weather map at the left.

Figure 14. Cold front occlusion.

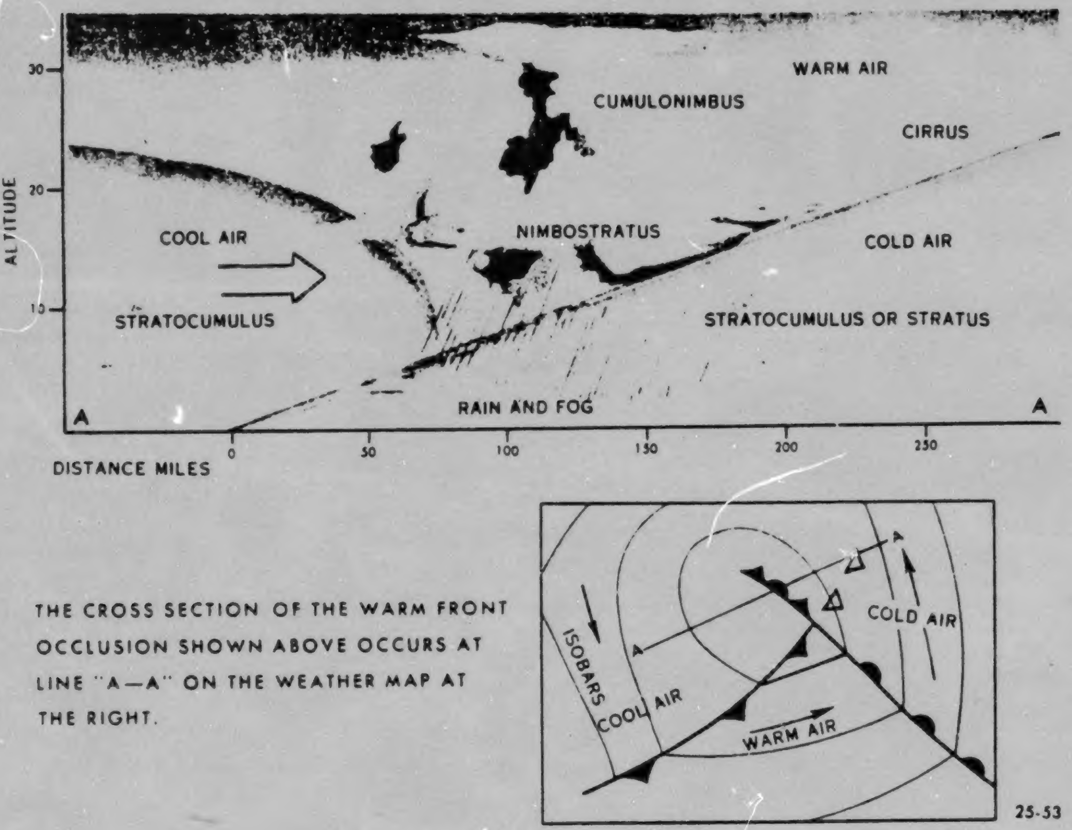
hind the advancing cold front. When the cold front overtakes the warm front, the cool (less dense) air behind the cold front slides up over the colder air ahead of the warm front. The air in the warm sector is again forced aloft. The warm front remains on the surface, and the cold front rides up over the warm frontal slope to become an upper cold front (cold front aloft). You should remember that the type of occlusion is named after the type of front that *remains on the surface.*

5-55. Figure 15 shows the weather and cloud patterns normally associated with the warm front occlusion. Occlusions combine the weather of the warm and cold fronts into one extensive system. The line of thunderstorms usually associated with a cold front merges with the low ceilings and visibilities of the warm front. However, there are a few significant differences in the weather between the two types of occlusions. The cloud system with the warm front occlusion is much wider than that with the cold front occlusion because the warm frontal surface extends under the upper cold front. This causes the weather pattern with a warm occlusion to be very similar to that of a warm front. A line of thunderstorms with the warm front occlusion is often imbedded within the stratiform overcast layer and may precede the surface occlusion by 200 to 300 miles. The imbedded thunderstorms with the cold front occlusion usually occur with the passage of the surface occluded front. Clearing skies often occur shortly after passage of the occlusions.

5-56. Occluded frontal systems are more common in the northern portions of the United States than in the southern portions. Occlusions occur most frequently during the winter months; and, in the United States, in the northwest and northeast sections of the country. This concludes our discussion of general meteorology as it applies to your observing duties. Before proceeding to the section on mathematics and meteorological tables, refer to your workbook and answer the questions for this section.

6. Mathematics and Meteorological Tables

6-1. Because you solve mathematical problems in your day-to-day duties you must know certain mathematic fundamentals. This section discusses the procedures for interpolation of meteorological tables and then presents methods for constructing tables that you use, such as the altimeter setting, sea-level pressure, and cloud height tables.


WARM AIR
CUMULONIMBUS
CIRRUS
ALTITUDE
30
20
10
COOL AIR
NIMBOSTRATUS
COLD AIR
STRATOCUMULUS
STRATOCUMULUS OR STRATUS
RAIN AND FOG
A
A
DISTANCE MILES
0
50
100
150
200
250
A
A
COLD AIR
ISOBARS
COOL AIR
WARM AIR
25-53

THE CROSS SECTION OF THE WARM FRONT OCCLUSION SHOWN ABOVE OCCURS AT LINE "A—A" ON THE WEATHER MAP AT THE RIGHT.

Figure 15. Warm front occlusion.

6-2. **Interpolation.** Many times, when you use the pressure reduction tables, you must interpolate to obtain the correct sea-level pressure. Perhaps you are not familiar with the procedures for interpolation. Interpolation essentially means to insert computed values between given tabular values. To find the sea-level pressure for a station pressure of 29.850 inches at a mean temperature of 17° F., refer to table 3 and set up the interpolation of the table as shown in figure 16.

6-3. Step 1 shows the solution of the proportion to find the value that must be added to or subtracted from the sea-level pressure of 1038.3 mb for two-fifths of a difference of zero.

6-4. Step 2 shows the solution of the proportion to find the value that must be added to or sub-

TABLE 3
SEA-LEVEL PRESSURE REDUCTION TABLE
(NOT CORRECTED FOR MOISTURE)

	Station Pressure (Inches)							
	29.50	29.60	29.70	29.80	29.90	30.00	30.10	30.20
Temp °F	Sea Level Pressure (Mbs)							
-10	1028.8	1032.5	1035.9	1039.6	1043.0	1046.4	1049.8	1053.5
-5	1028.4	1032.2	1035.6	1039.3	1042.7	1046.1	1049.8	1053.2
0	1028.4	1032.2	1035.6	1038.9	1042.3	1046.1	1049.5	1053.2
5	1028.1	1031.8	1035.2	1038.6	1042.3	1045.7	1049.1	1052.8
10	1027.8	1031.5	1034.9	1038.6	1042.0	1045.4	1048.8	1052.5
15	1027.8	1031.5	1034.9	1038.3	1042.0	1045.4	1048.8	1052.5
20	1027.4	1031.2	1034.5	1038.3	1041.7	1045.0	1048.4	1052.2

	29.80 INS.	29.85 INS.	29.90 INS.
15°F	1038.3		1042.0
17°F	1038.3	1040.1	1041.9
20°F	1038.3		1041.7

STEP 3 ↔

STEP 1 ↕ STEP 2 ↕

STEP 1. 2/5=X/0 ∴ 5X=0, X=0

STEP 2. 2/5=X/3 ∴ 5X=.6, X=.12

STEP 3. 5/10=X/3.6 ∴ 10X=18.0, X=1.8

25-66

Figure 16. Interpolation for sea level pressure.

tracted from the sea-level pressure of 1042.0 mb for two-fifths of the difference of 0.3.

6-5. Step 3 shows the cross-interpolation for one-half of the difference in pressure for a change of 3.6 mb.

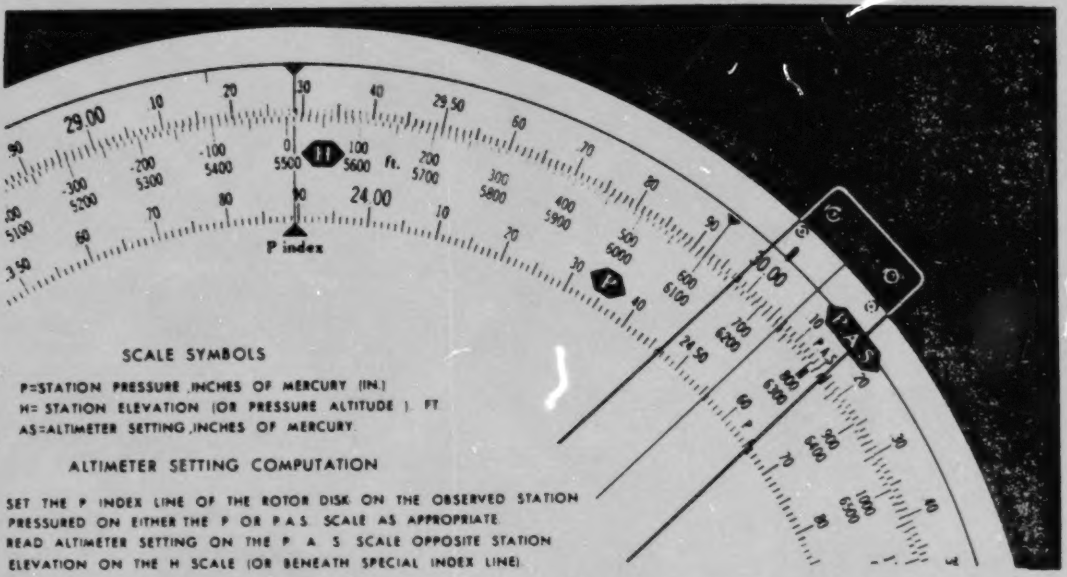
6-6. By interpolation, you find that the sea-level pressure for this problem is 1040.1 mb. A moisture factor may be incorporated into sea-level computations, but since this factor is so small, it is seldom used.

6-7. Nothing more need be said concerning interpolation procedures, for the actual task of obtaining table values will strengthen your knowledge of this subject. Our next subject, table preparation, discusses methods for constructing various meteorological tables.

6-8. **Table Preparation.** The weather station at which you are assigned should, and probably does, have prepared tables you can use to determine altimeter setting, sea-level pressure, and cloud height values. However, there are times when you may have to construct new tables from "scratch." This could occur when you move to a new observation site, or when your current tables do not have enough range to cover extreme variations. Our discussion of table preparation begins with two methods used to construct altimeter setting tables.

6-9. *Altimeter setting table*. There are several methods that can be used to construct altimeter setting tables. The two most common methods are the *WBAN Manual of Barometry* method and the method used in conjunction with the *Pressure Reduction Computer* (WBAN 54–7–8). When using the computer, the only information you need to obtain an altimeter setting is the station pressure and the station elevation. Figure 17 is an example of altimeter setting computation using the computer.

6-10. The first step, when using the computer, is to obtain the station pressure to the nearest 0.005 inch. Then using side II of the computer, set the P index to the obtained station pressure value on either the P or P.A.S. scale, as appropriate. Align the cursor over the station elevation on the H scale. Finally, under the cursor on the P.A.S. scale, read the indicated altimeter setting value to the nearest hundredth of an inch. Figure 17 illustrates how the computer is set up using a station pressure of 29.290 inches and a station elevation



SCALE SYMBOLS

P=STATION PRESSURE ,INCHES OF MERCURY (IN.)
H= STATION ELEVATION (OR PRESSURE ALTITUDE) FT
AS=ALTIMETER SETTING ,INCHES OF MERCURY

ALTIMETER SETTING COMPUTATION

1. SET THE P INDEX LINE OF THE ROTOR DISK ON THE OBSERVED STATION PRESSURED ON EITHER THE P OR P.A.S. SCALE AS APPROPRIATE
2. READ ALTIMETER SETTING ON THE P A S SCALE OPPOSITE STATION ELEVATION ON THE H SCALE (OR BENEATH SPECIAL INDEX LINE)

25-67

Figure 17. Example of altimeter setting computation on computer.

of 737 feet. These values produce an altimeter setting of 30.07 inches. Now add .01 inch to this computed altimeter value in order to arrive at a value with reference to *field elevation*.

6-11. Our second method of computing an altimeter setting is the *Manual of Barometry* method. This method requires that you use tables 8.1–1 through 8.1–4 that are contained in the manual. To illustrate the actual procedure when using this method, we have included an extract of a portion of table 8.1 (see Appendix A) in this volume. To compute altimeter settings by this method, use the following steps:

a. Refer to the body of the table in Appendix A and find the pressure altitude corresponding to your corrected station pressure.

b. Subtract, algebraically, your station elevation from the pressure altitude obtained from the table.

c. Go back to the table again. Take the value obtained from step *b* and find this value in the table. Its pressure equivalent is the altimeter setting.

TABLE 4

STATION PRESSURE TO ALTIMETER SETTING CONVERSION TABLE

Podunk Air Force Base, Iowa

Station Elevation: 745 ft

Station Pressure (Inches)	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
28.40	29.17	29.18	29.19	29.20	29.21	29.22	29.23	29.24	29.25	29.26
28.50	29.27	29.28	29.29	29.30	29.31	29.31	29.32	29.33	29.34	29.36
28.60	29.37	29.38	29.39	29.40	29.42	29.43	29.44	29.45	29.46	29.47
28.70	29.48	29.49	29.50	29.51	29.52	29.53	29.54	29.55	29.56	29.57
28.80	29.58	29.59	29.60	29.61	29.62	29.63	29.64	29.65	29.66	29.67
28.90	29.68	29.69	29.70	29.71	29.72	29.73	29.74	29.75	29.76	29.77
29.00	29.78	29.79	29.80	29.81	29.82	29.83	29.84	29.85	29.86	29.87
29.10	29.89	29.90	29.91	29.92	29.93	29.94	29.95	29.96	29.97	29.98
29.20	29.99	30.00	30.01	30.02	30.03	30.04	30.05	30.06	30.07	30.08
29.30	30.09	30.10	30.11	30.12	30.13	30.14	30.15	30.16	30.17	30.18
29.40	30.19	30.20	30.21	30.22	30.23	30.24	30.25	30.26	30.27	30.28
29.50	30.29	30.30	30.31	30.32	30.33	30.35	30.36	30.37	30.38	30.39
29.60	30.40	30.41	30.42	30.43	30.44	30.45	30.46	30.47	30.48	30.49
29.70	30.50	30.51	30.52	30.53	30.54	30.55	30.56	30.57	30.58	30.59
29.80	30.60	30.61	30.62	30.63	30.64	30.65	30.66	30.67	30.68	30.69
39.90	30.70	30.71	30.72	30.73	30.74	30.75	30.76	30.77	30.78	30.79
30.00	30.80	30.82	30.83	30.84	30.85	30.86	30.87	30.88	30.89	30.90
30.10	30.91	30.92	30.93	30.94	30.95	30.96	30.97	30.98	30.99	31.00
30.20	31.01	31.02	31.03	31.04	31.05	31.06	31.07	31.08	31.09	

6-12. Now work through a sample problem. Chanute AFB has a station elevation of 747 feet. At a given time the station pressure is 29.090. Follow the steps given above and use Appendix A. Remember we want field elevation for our starting point. Your computations should produce the following results:

Step a Station pressure = 29.090.

Step b Pressure altitude value for 29.090 = 778.

Step c Now subtract the station elevation algebraically, 778 − 747 = +31 ft.

Step d Within the table we find that this "+31" corresponds to a pressure of 29.89 inches. (In some cases, interpolation may be necessary.)

This is the altimeter setting for a station pressure of 29.090.

6-13. When preparing altimeter tables, keep in mind that you must start with the lower and upper limits of the observed extreme station pressure values. This information can be obtained from the station Climatic Data Summaries. Table 4 is an example of a completed station pressure to altimeter setting conversion table. As you can see, this table was constructed using 28.400 and 30.280 inches as the extreme values of observed station pressure.

6-14. Our next subject, sea level pressure reduction tables, is very similar in method of computation to that of the altimeter tables.

6-15. *Sea level pressure reduction table.* You can reduce the observed station pressure to sea level pressure by either of two methods—by using prepared pressure reduction tables or the Pressure Reduction Computer. The quickest and most accurate method is to use the computer. Side I of the computer is used to compute sea level pressure values. This side is calibrated in millibars and inches of mercury (pressure) and has a movable scale calibrated in "r" values (the ratio of sea level pressure to station pressure per increment of 12-hour mean temperature in degrees F.).

6-16. To reduce station pressure to sea level using the computer, follow this procedure. First, use the station pressure as it is recorded (nearest 0.005 inch of mercury). Next, determine the 12-hour mean temperature. Then, using side I of the computer, set the P index to the current station pressure on the P scale (inches). Determine the

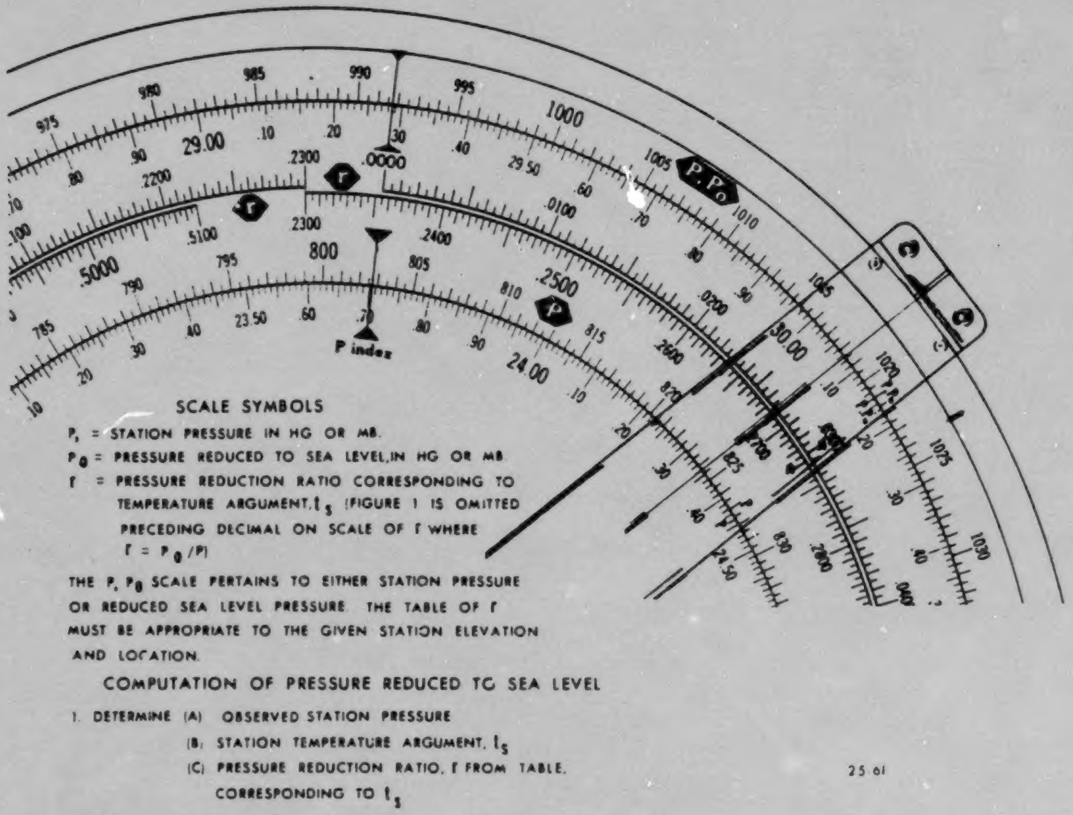

975
980
985
990
995
1000
1005
1010
29.00
29.50
30.00
2200
2300
2400
2500
2600
800
805
810
815
795
790
785
23.50
24.00
24.50
P index
P, P₀
r
P
SCALE SYMBOLS
P, = STATION PRESSURE IN HG OR MB.
P₀ = PRESSURE REDUCED TO SEA LEVEL,IN HG OR MB
r = PRESSURE REDUCTION RATIO CORRESPONDING TO TEMPERATURE ARGUMENT, tₛ (FIGURE 1 IS OMITTED PRECEDING DECIMAL ON SCALE OF r WHERE r = P₀/P)
THE P, P₀ SCALE PERTAINS TO EITHER STATION PRESSURE OR REDUCED SEA LEVEL PRESSURE. THE TABLE OF r MUST BE APPROPRIATE TO THE GIVEN STATION ELEVATION AND LOCATION.
COMPUTATION OF PRESSURE REDUCED TO SEA LEVEL
1. DETERMINE (A) OBSERVED STATION PRESSURE
(B) STATION TEMPERATURE ARGUMENT, tₛ
(C) PRESSURE REDUCTION RATIO, r FROM TABLE, CORRESPONDING TO tₛ
25 61

Figure 18. Example of sea level pressure computation on computer.

In. Hg	.00	.01	.02	.03	.04	.05
27.00	914.33	914.66	915.00	915.34	915.68	916.02
27.10	917.71	918.05	918.39	918.73	919.07	919.40
27.20	921.10	921.44	921.78	922.11	922.45	922.79
27.30	924.48	924.82	925.16	925.50	925.84	926.18
27.40	927.87	928.21	928.55	928.89	929.23	929.56
27.50	931.26	931.60	931.93	932.27	932.61	932.95
27.60	934.64	934.98	935.32	935.66	936.00	936.34
27.70	938.03	938.37	938.71	939.05	939.38	939.72
27.80	941.42	941.75	942.09	942.43	942.77	943.11
27.90	944.80	945.14	945.48	945.82	946.16	946.50
28.00	948.19	948.53	948.87	949.20	949.54	949.88

"r" value by using the mean temperature and the table of "r" values for your station that is supplied with the computer. Align the computer cursor with the derived "r" scale value. Under the cursor on the outer (P_o) scale, read the sea level pressure in millibars. Figure 18 illustrates the proper alignment of the scales and cursor for the following values:

station pressure = 29.285 inches
"r" value (derived from table using a 12-hr mean temp of 75° F.) = .0269

These values produce a sea level pressure of 1018.4 mb.

6-17. This method of computing sea level pressure is much simpler than using pressure reduction tables; therefore, it is used at most AWS stations. If you do have to prepare sea level pressure reduction tables, you must prepare them in accordance with FMH 8, *WBAN Manual of Barometry*.

6-18. The FMH 8 uses a basic formula for determining sea level pressure values. Let's begin by putting down the formula and identifying its parts.

$$P_o = P \times r \text{ (where } r = \frac{KHpg}{Tmv}\text{)}$$

P_o = Sea level pressure.
P = Station pressure.
r = Ratio of sea level pressure to station pressure for each degree of temperature.
K = a constant value of 0.0266895° R. (This value is built into the table of "r" values.)
Hpg = represents the difference between two known heights or your station elevation in meters.
Tmv = 12-hour mean temperature expressed in degrees Rankine.

Now, work an example problem by substituting the following values into the formula.

Observed station pressure = 27.00 inches of mercury
Station elevation = 500 meters
12-hour mean temperature = 50° F.

6-19. Using table 5 (an extract from FMH 8), convert 27.00 in. Hg to pressure in millibars (914.33mb). Then convert the 12-hour mean temperature from the Fahrenheit scale to the Rankine scale using R. = 459.7 + °F., which produces a value of 509.7° R. Now using table 6 (extracted from FMH 8), locate the station elevation value and enter the table to where it coincides with

TABLE 6
DERIVED "R" VALUE TABLE

Ratio of SEA-LEVEL Pressure to STATION PRESSURE as a function of 12-hour mean temperature in degrees Rankine ("r" value)

Station elevation in Meters	12-hour mean temperature in degrees Rankine				
	500	505	510	515	520
500 - - -	1.06338	1.06275	1.06211	1.06148	1.06086
510 - - -	1.06468	1.06402	1.06338	1.06275	1.06214
520 - - -	1.06601	1.06532	1.06466	1.06402	1.06338
530 - - -	1.06731	1.06662	1.06596	1.06530	1.06463
540 - - -	1.06861	1.06792	1.06723	1.06657	1.06591
550 - - -	1.06994	1.06923	1.06851	1.06782	1.06714
560 - - -	1.07125	1.07053	1.06982	1.06910	1.06842
570 - - -	1.07258	1.07182	1.07110	1.07038	1.06970
580 - - -	1.07389	1.07312	1.07238	1.07167	1.07095
590 - - -	1.07520	1.07443	1.07369	1.07295	1.07221
600 - - -	1.07654	1.07575	1.07498	1.07421	1.07349

TABLE 7
PORTION OF A SEA-LEVEL REDUCTION TABLE

Mean Temp (°F)	Station	Pressure	(Inches)
	27.00	27.10	27.20
30			
35			
40			
45			
50	971.1	etc.	
55			
60			

the Rankine temperature. The Rankine temperature of 509.7° is rounded off to 510° R. giving us a value for "r" of 1.06211. Our final step in arriving at the sea level pressure is to multiply the station pressure millibar value by the derived "r" value as follows:

914.33mb × 1.06211

This produces a sea level pressure of 971.1 mb.

6-20. You can now start the sea level pressure reduction table with temperatures listed along the left side and station pressures along the top, as shown in table 7. In the space at the intersection of temperature = 50° F. and station pressure = 27.00 inches, you enter 971.1. As you work out the SLP (sea level pressure) for different pressures and mean temperatures, enter them in the table as we did in the example problem. Remem-

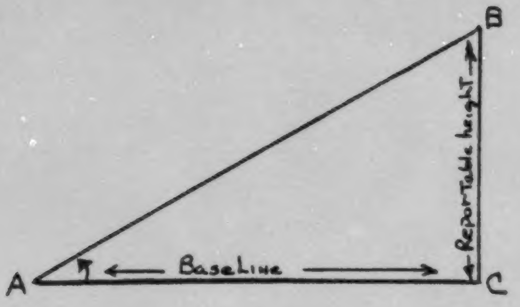


Figure 19. Determining angle A using the tangent function.

ber, when you vary the temperature or pressure, you must compute a new constant ("r" value). You must also include enough values in the table to cover the pressure and temperature range of your station. Our final discussion on table preparation deals with the cloud height table.

6-21. *Cloud height table.* Preparing cloud height tables involves the use of some trigonometry. We will not discuss all the functions used in trigonometry. Our discussion will center solely on the *tangent function* used to determine angles that correspond to reportable cloud height values. In a right triangle such as shown in figure 19, the angle that we are solving for involves only the tangent function. This figure shows that we have two given values for two sides of the triangle—AC (the baseline) and BC (a reportable cloud height value).

6-22. To solve for angle A, use the natural tangent ("NAT") values from Appendix B of this volume and the tangent function of angle A. To arrive at a "NAT" value for angle A, you have to divide the opposite side by the adjacent side. After arriving at the "NAT" value, you enter Appendix B and find the tangent angle that corresponds to your "NAT" value.

6-23. Cloud heights must be encoded to conform to specified reportable values. That is, 100-foot increments up to 5000 feet; 500-foot increments between 5000 feet and 10,000 feet; and 1000-foot increments above 10,000 feet. Using these resportable values you can set up a cloud height table with the reportable values on one side, then determine their corresponding angles to put on the other side by use of the tangent function of angle A.

6-24. The equation $\tan A = \frac{\text{opp}}{\text{adj}}$ enables us to determine the range of angles that correspond to a given reportable height. This eliminates the need to compute each angle separately.

6-25. Recall from school that when a cloud height occurs between zero and 50 feet, it is rounded off to a reportable value of "0," and those between 51 and 150 feet are rounded off to a reportable value of "100," and so on. Now that you know the height range for which you need to compute the angles, work through a few examples.

6-26. Using a baseline of 400 feet, start the cloud height table by putting the reportable height values on the left and then determine the angles that correspond to the particular height. Table 8 is an example of a cloud height table using a 400-foot baseline. The angles in the table were determined by using the midpoint value of each reportable height; that is, 50 feet, then 150, 250, and so on. The reason for this is that values up through the midpoint are reported at the lower reportable height.

6-27. Appendix B contains the "NAT" tangent values for all angles between 0° and 90°. Using the tangent function of angle A, now go through a few angle computations. With a 400-foot baseline the equation becomes.

$$\tan A = \frac{\text{opp}}{400}$$

$$\text{If opp} = 50 \text{ feet}$$

$$\text{Then, } \tan A = \frac{50}{400}$$

$$= .1250 \text{ ("NAT" tangent value)}$$

TABLE 8
PORTION OF A CLOUD HEIGHT TABLE
(400-FOOT BASELINE)

Height (Feet)	Angle
0	<8°
100	8°-20°
200	21°-32°
300	33°-41°
etc.	

Refer to Appendix B and find the tangent angle that corresponds to .1250. To do this, in the tangent column under "NAT," we find that 0.1250 falls between .1228 and .1257 which correspond to 7°00′ and 7°10′. Therefore, the angle entry in table 8 for cloud heights 0 through 50 feet (reportable value "0") is "<8°" for less than 8°.

6-28. Let's continue on and compute several more values for the table:

Example 1:

$$\tan A = \frac{150}{400}$$
$$= .3750$$
$$A = 20° \text{ approx.}$$

Based on the previous computation and this latter one, our angle entry in table 8 for the reportable height of 100 feet will be 8° to 20°.

Example 2:

$$\tan A = \frac{250}{400}$$
$$= .6250$$
$$A = 32°$$

Therefore the entry for 200 feet in table 8 is 21° to 32°.

Example 3:

$$\tan A = \frac{350}{400}$$
$$= .8750$$
$$A = 41°$$

The entry in table 8 for 300 feet is 33° to 41°.

6-29. You may want to include intermediate heights in the table in addition to the reportable height values. However, this section is primarily concerned with showing you how to determine the angles that correspond to the reportable height values. This discussion showed you how to prepare cloud height tables using the tangent function of angle A. Using the simple equation given, you can find accurate values for cloud heights, and also check your existing tables.

6-30. This concludes our discussion of table preparation. Now that you know the procedure for preparing cloud height tables, the next subject in Chapter 3, Weather Station Equipment, should be easier to understand. But before proceeding to the next chapter, refer to your workbook and answer the questions for this last section.

CHAPTER 3

Weather Station Equipment

AN ACCURATE, representative observation of the surface weather elements relies heavily upon your good judgment and well-developed job skill. Instruments devised for measuring basic weather elements, such as temperature, pressure, and wind, help to shorten the time you take to observe these elements. You must develop skills in operating these instruments so that you can employ them to their advantage. The instruments do not replace you but rather increase your effectiveness as an observer.

2. Observation of all the weather elements, in some way, involves a measuring device. Some instruments are simple in construction; but others have highly complex electronic circuitry. However, regardless of its construction, as you look at the equipment installed at your station, one overall purpose of design is obvious—to provide a one-location readout of as many basic weather elements as possible. This chapter discusses the basic operating methods for obtaining the best measurement from cloud height measuring sets, visibility measuring sets, precipitation gage, pressure instruments, temperature-humidity equipment, and wind measuring sets. The equipment chosen for discussion represents the inventory found at most fixed observing sites. Figure 20 depicts a possible layout for a weather facility. Notice that the airfield is multiple-instrumented, i.e., it has wind, visibility, and ceiling measurements for each runway. Some airfields have all the runway approaches instrumented. The figure shows ceiling height measurement as one of the important elements of weather support to flying operations. This section begins with a discussion of equipment used to obtain ceiling heights.

7. Manipulating Surface Observing Equipment

7-1. Your training thus far has provided you with a basic skill for turning equipment ON and OFF and for identifying controls. Your objective in this section is to acquire some operating methods for obtaining proper measurement from surface observing equipment. For a more detailed description of the component parts, nomenclature, and principles of equipment operation, consult the current technical order. Minor preventive maintenance is discussed in a later section of this volume.

7-2. **Cloud Height Measuring Sets.** Two sets receive our attention here—AN/GMQ-13, Cloud Height Set and AN/TPQ-11, Radar Cloud Detecting Set. Both sets are fixed installation. Other sets such as the mobile AN/TMQ-14 and the portable AN/TMQ-2 are discussed as component parts of tactical observing systems.

7-3. *Cloud Height Set, AN/GMQ-13.* Often called the rotating beam ceilometer (RBC) because the projected light beam rotates through its measuring arc, the GMQ-13 offers several advantages. First, a rapid measuring sweep provides several measurements without tying up much observation time. Second, a dual light system allows height measurement even though one light burns out. Third, the baseline length allows height measurements between a range of 50 to 4000 feet with a reasonable degree of accuracy.

7-4. The length of the baseline determines the maximum height that clouds can be considered measured with accurate accuracy for observational purposes. Shortening the baseline to less than the 400 feet, most widely used in AWS, decreases the maximum height of accurate measurement. Increasing the baseline improves the range of accurate measurements, but for a baseline of 1000 feet or longer, other limiting factors arise. They include light beam cutoff by low hanging cloud fragments, attenuation of the light beam intensity by fog or other obstructions to vision, and diffusion of the light beam by water droplets.

7-5. The presence of low cloud or fog governs the period of ceilometer operation. The ceilometer should be turned on whenever one of the following conditions exists at your station.

a. When clouds are present within the height measuring capability of the set or fog is present.

b. When either of the above conditions are forecast or expected to be present within 3 hours.

c. When a local need exists.

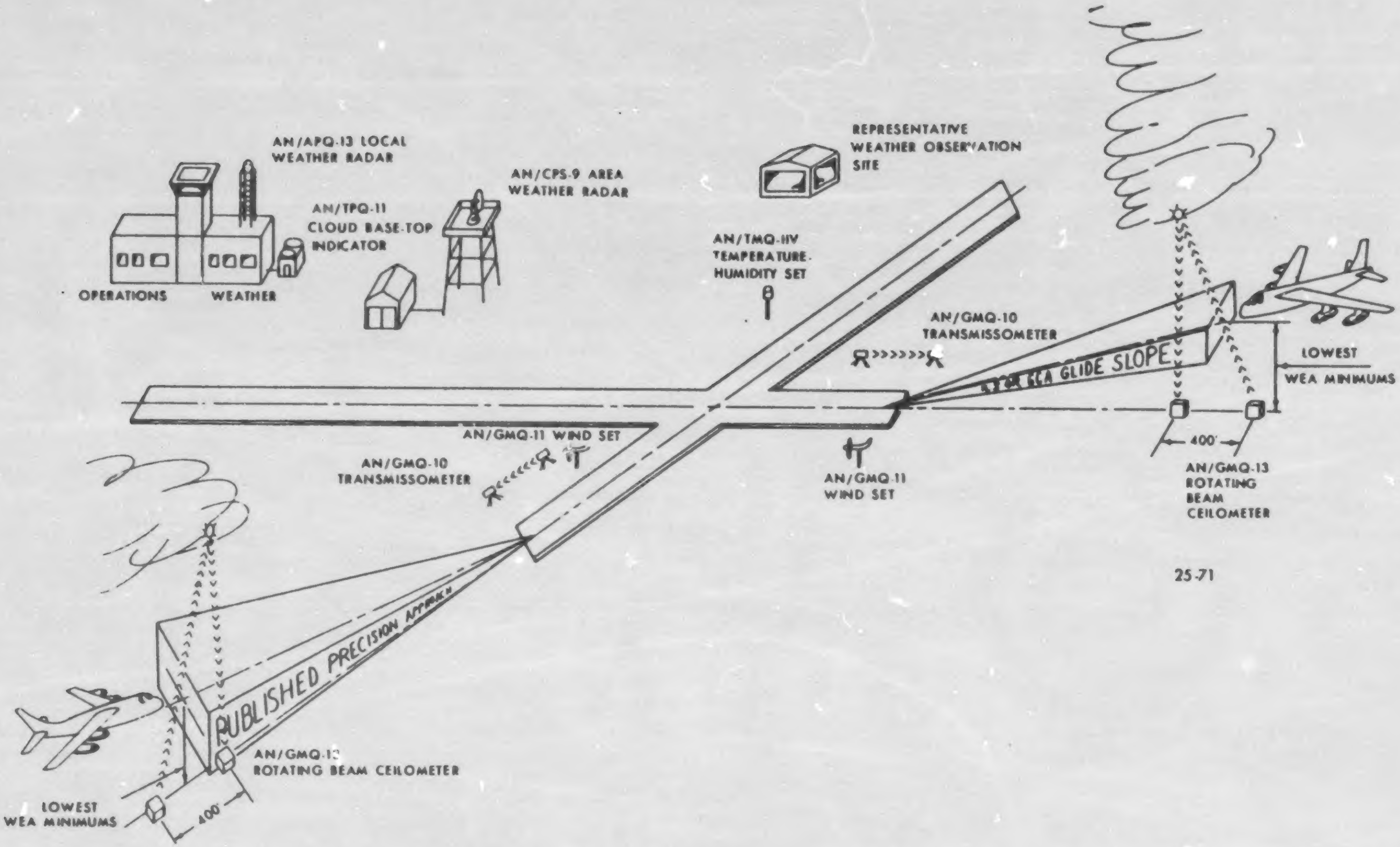
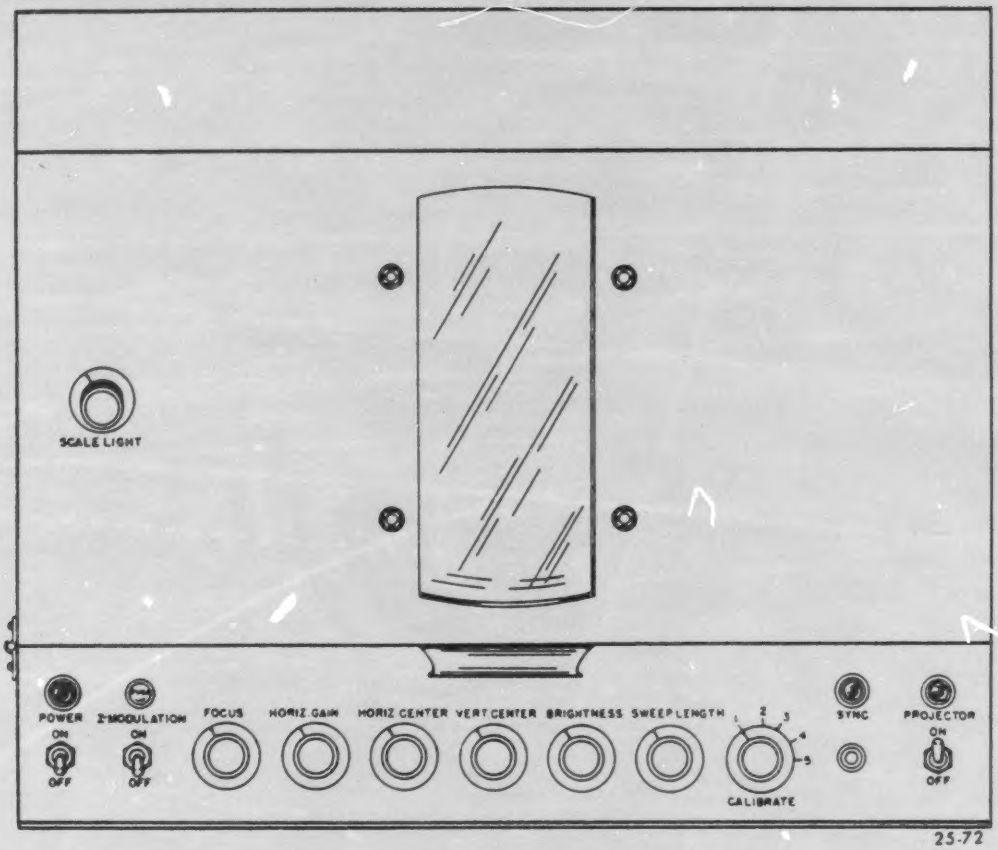

AN/APQ-13 LOCAL WEATHER RADAR
AN/TPQ-11 CLOUD BASE-TOP INDICATOR
AN/CPS-9 AREA WEATHER RADAR
OPERATIONS
WEATHER
REPRESENTATIVE WEATHER OBSERVATION SITE
AN/TMQ-11V TEMPERATURE-HUMIDITY SET
AN/GMQ-10 TRANSMISSOMETER
GLIDE SLOPE
LOWEST WEA MINIMUMS
AN/GMQ-11 WIND SET
AN/GMQ-10 TRANSMISSOMETER
AN/GMQ-11 WIND SET
400'
AN/GMQ-13 ROTATING BEAM CEILOMETER
25-71
PUBLISHED PRECISION APPROACH
AN/GMQ-13 ROTATING BEAM CEILOMETER
LOWEST WEA MINIMUMS
400'

Figure 20. Location of weather equipment for representative observations.



25-72

Figure 21. GMQ-13 indicator controls.

When none of these conditions exists or is expected to occur within 3 hours, you may keep the ceilometer in standby. The height measuring capability of the set depends upon the baseline length and the ceilometer in use. Though we are primarily discussing the GMQ-13, the conditions during which the ceilometer is to be operated apply to the TMQ-14 as well. The TMQ-14 measuring range is considerably shorter than the GMQ-13. AWSP 105-3 describes the effective range of the GMQ-13 using a 400 foot baseline as 4500 feet. The same pamphlet recognizes the TMQ-14 effective range as 2100 feet using a 300 foot baseline. These heights can be considered as the height measuring capability of the respective sets.

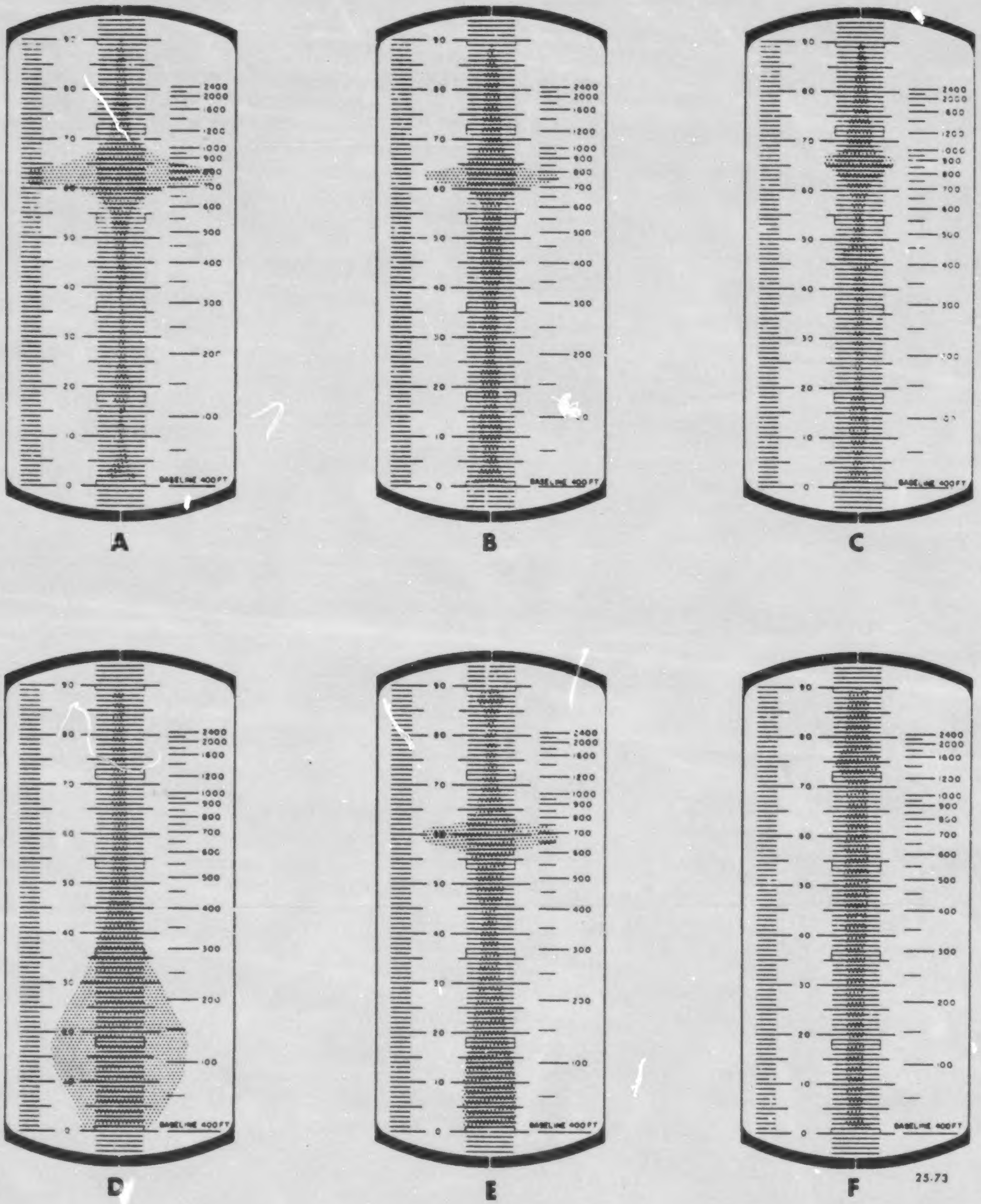
7-6. To obtain height readings from the ceilometer you must be able to adjust the sweep, read the scales, and interpret the scope. Figure 21 shows the controls used when adjusting the sweep. After you turn on the POWER and Z MODULATION toggle switches, begin sweep adjustment by turning the BRIGHTNESS control clockwise until the sweep appears on the scope. Use the HORIZONTAL CENTER control to make the sweep run along the vertical centerline of the scale, and adjust the FOCUS to obtain the sharpest beam. Place the CALIBRATE switch in each position and adjust as follows:

- Position number 5. Sweep should appear at 0°. Adjust with SWEEP LENGTH control.
- Position number 4. Sweep should appear at 90°. Adjust with SWEEP LENGTH control.
- Position number 3. Sweep should appear at 45°. Adjust with VERT CENTER control.
- Position number 2. Sweep flashes in each of the rectangles on the scale. If not, readjust other calibration settings.

After these adjustments, the sweep should trace the proper length along its scale. Place the CALIBRATE switch to position number 1, and adjust HORIZ GAIN until about ⅛ inch of noise (sweep width) is present. During sweep adjustment, the PROJECTOR switch has been off. When you turn it on you may find the projector and indicator are not working in harmony.

7-7. The indicator also uses a pulse that shows when the indicator is synchronized (or in harmony) with the projector. The "sync" pulse appears as a short step that is displaced to the right of the sweep path. The sync pulse should appear at the bottom 2° of the sweep. If the sync pulse appears anywhere else, push the SYNC button momentarily. The indicator sweep comes to rest at 0° until it becomes synchronized with the projector. During the 0° rest time, the SYNC lamp is lit. When synchronization is achieved, the indicator sweep automatically begins its cycle.

7-8. To accurately read the indicator scales, you must keep one caution in mind. The measured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BASELINE 400 FT
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Figure 22. RBC scope interpretation.

height changes rapidly as the elevation angle approaches 90°. In other words, a small change in elevation angle indicates a large change in measured height. Height indications registered above 75° elevation angle must be carefully observed to avoid misreading the scale by one or more reportable values.

7-9. Interpretation of the patterns appearing on the scope requires experience more than anything else. As an aid, a few typical patterns are illustrated in figure 22. These illustrations present only generalized pictures and do not portray the many variations that occur within each pattern. A brief discussion of details A through F of figure 22 follows.

a. Details A, B, and F are single-cloud indications. As the projector beam shines on the cloud directly over the detector, the scope trace widens. The base of the cloud is at the base of the widest part of the scope trace. Detail A shows an abrupt deflection that places the base at 60° and 700 feet. The trace in detail B widens less abruptly with the widest point at 62° and 750 feet. These two details show clouds whose bases are well defined, such as cumulus clouds. Detail F shows a diffuse or less defined cloud base, such as the base of a stratus cloud. The scope depicts the base at 75° and 1500 feet.

b. Detail C apparently presents two cloud layers at 46° and 65°. When multiple layers appear on the scope, you had better verify their existence by an outside visual observation, if possible. Do this to avoid reporting a noise signal as a cloud layer.

c. Detail D depicts a low ceiling accompanied by fog at the surface. The fog causes the wide trace at the surface. The base of the cloud is indicated at the widest part of the bulge or about 100 feet.

d. Detail E shows two features. Reflection of the light by falling snow causes a wide trace at the surface. However, enough of the projected light reaches through the snow to strike the cloud base at 60°. Frequently, precipitation or dense surface fog reduces the amount of projected light received at the photocell so that only the tapered portion of the trace appears, such as shown in detail E from the surface to 400 feet. A tapered trace should help in estimating the vertical visibility into the phenomenon.

e. Another feature in details A, B, and C needs to be mentioned. Notice the bulging trace in detail A at about 20°, again in detail B at 10° and 20°, and also in detail C at 15°. These depict noise signals that are generated either within the set or from external radio or light sources. Noise signals are often characterized by their random patterns; that is, they do not appear as a fixed signal from scan to scan. Also, a signal appearing between measuring scans, when no signal information is being presented, gives a further indication that you are receiving noise. High-intensity flasher interference does cause regularly spaced signal reactions about 15° apart on the indicator scope. Noise signals also show narrow, sharp deflections as well as the gradual bulges shown in the illustrations. Although you cannot eliminate noise signals, you can reduce their effect upon the scope trace by turning the HORIZ GAIN control to a lower setting.

7-10. *Radar Cloud Detecting Set, AN/TPQ-11.* The limitation of the light beam type of cloud height measuring set, and the need to know the height of cloud tops and data concerning multiple layers of clouds, led to the development of the radar cloud detecting set. The vertical radar set detects targets through a height range that is adequate to cover the vertical extent of clouds. The AN/TPQ-11 can detect clouds from 500 to 60,000 feet. Another fea-

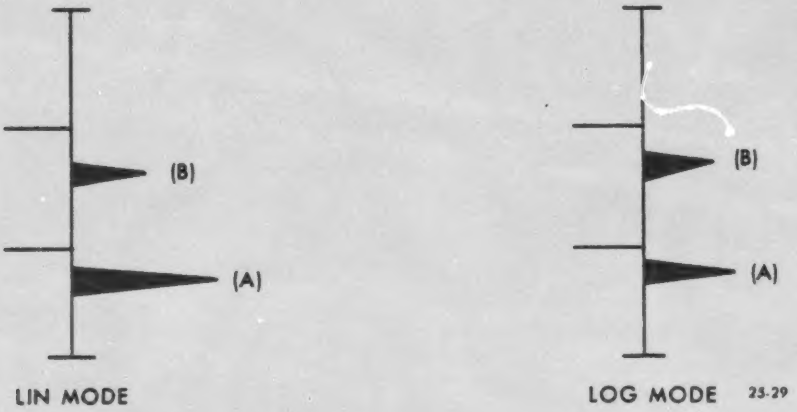


Figure 23. Comparison of TPQ-11 LIN and LOG modes.

ture of the TPQ–11 is its sensitivity. It can detect the thinner or less dense clouds (smaller droplet size). To achieve this increased sensitivity, however, attenuation of the signal is more pronounced during precipitation or in low, heavy clouds.

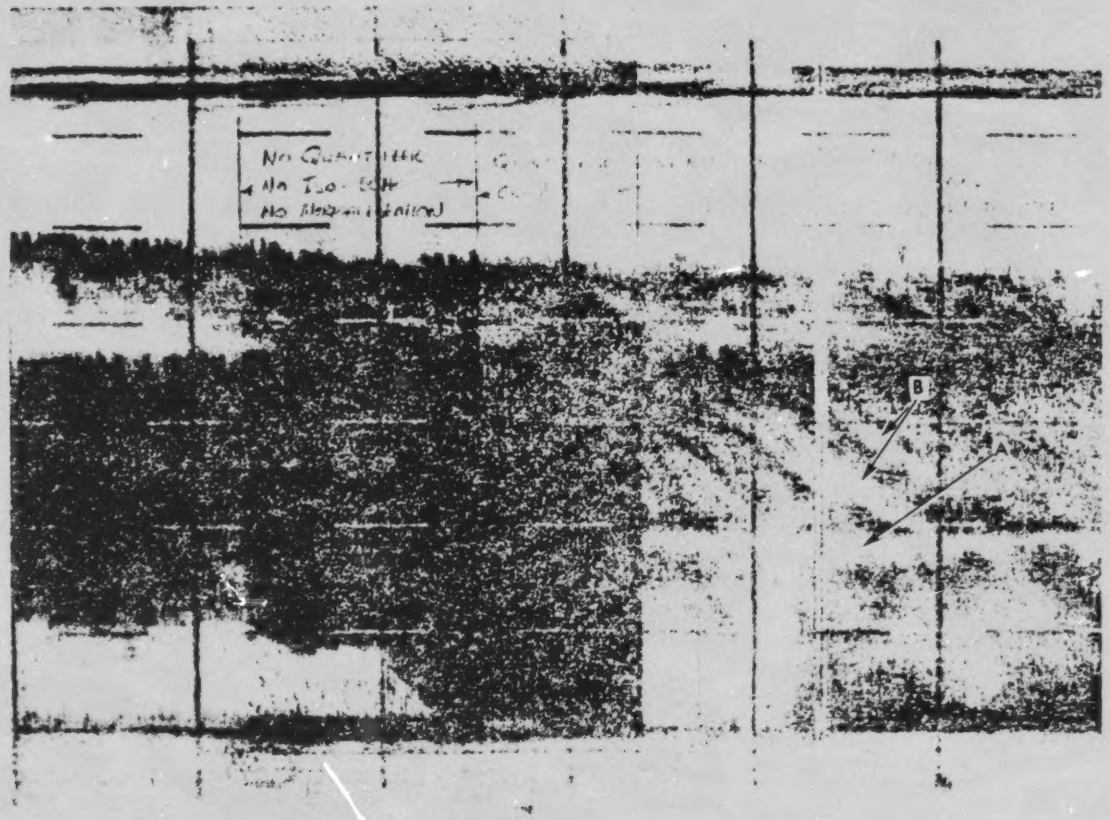
7-11. Clouds and precipitation, passing through the vertical radar beam, "paint" patterns on the scope and are displayed upon the recorder. The quality and usefulness of the patterns depend upon the control settings. Knowing the effects of some controls can increase your understanding of the scope presentation. The controls are on the console indicator panel.

7-12. The RANGE SELECTOR control does what the name implies—selects one of the three available height ranges for presentation. Obviously, greater cloud detail is available at the low height range if the clouds are below 15,000 feet. Regardless of the range selected, the TPQ–11 is inaccurate below 500 feet.

7-13. Another control that affects the scope presentation is the IF ATTENUATOR. This adjusts the level of the signal input, and it is possible to eliminate the signal presentation on the scope by increasing the attenuation. Therefore, when you evaluate a scope presentation, the amount of attenuation applied to the signal is important.

7-14. Another type of attenuation is provided by the RANGE NORMALIZATION control. This control can normalize signals to either 15,000 or 30,000 feet. Normalizing to 15,000 feet means that any echo signal returning from less than 15,000 feet is displayed with the same intensity it would have at 15,000 feet. Low altitude returns normally appear more intense than high altitude returns simply because the low returns are closer to the receiving antenna. Normalizing helps to equalize intensity differences due to range only. Also, blocking of high altitude returns by low altitude returns is reduced. Observing multiple cloud layers is aided by the use of normalization especially when the strongest signals come from the lower layers.

7-15. You may operate the TPQ–11 receiver in either linear (LIN) mode or logarithmic (LOG) mode. The mode determines how the returned echo power is displayed. Figure 23 illustrates, graphically, how each mode differs. Consider two



25 30

Figure 24. TPQ–11 echo record.

TABLE 9

TPQ–11 CONTROL SETTINGS

Character of Weather	Log/Lin Mode	Range Normalization	Quantize	ISO-Echo
Clouds, No Precip.	Log	Off	Yes	On
Rain or Drizzle	Log	15000	Yes	On
Snow	Lin	15000	No	Off
Multiple Cloud Layer - Strong Low Level Echo	Log	15000 or 30000	Yes	On

echoes (A) and (B). Assume that echo (A) is twice as intense as echo (B). LIN mode displays echo (A) with twice the length on the scope as echo (B). Echo display is in linear proportion to echo intensity. LOG mode displays echo intensity according to the logarithm of returned echo power. You can see from LOG mode in figure 23 that echo (A) is not displayed with twice the length of echo (B) even though their intensity remains the same as in LIN mode. For echo (A) to appear twice as long as echo (B) in LOG mode, (A) would have to become 10 times more intense than (B). The advantage of LOG mode is that a wide range of power returns can be shown without reaching the display limits of the scope.

7-16. Two other controls affect the display of echoes on the TPQ–11 facsimile recorder. First of these is the QUANTIZE control. The QUANTIZER separates all echo returns into three power steps and displays these steps as three levels of facsimile shading. These levels of shading are commonly referred to as "gray levels." The lightest shade of gray level represents all echoes with a power return between 0 and 10 decibels (db) above noise level. (A decibel is a measure of signal intensity.) An echo whose power return equals 2 db above noise level is recorded at the same gray level as an echo whose power return equals 10 db above. The darkest gray level covers the range between 20 db–30 db above noise. By using the QUANTIZE control, you can easily distinguish three levels of echo intensity without making any other control adjustments.

7-17. The second of the two controls affecting the facsimile display is the ISO-ECHO. This control eliminates the display of all echo returns that are greater in power than the darkest shade of gray level, i.e., greater than 30 db above noise level. Thus, the very strongest echo returns will appear as white, open areas within the shaded areas of echo display. To be valid, both the ISO-ECHO and QUANTIZE controls should be operated in LOG mode. The sample recorder strip in figure 24 compares the echo display under various control settings. Details within the cloud echo become noticeably better when the echo is quantized, iso-echoed, and normalized. The bright band (melting level) stands out (A); also evident are shafts of more intense echo (B) and a wind shear feature revealed by the slant of the intense shafts (B).

7-18. Except for special situations, operate the TPQ–11 in LOG mode and the facsimile data converter in QUANTIZE position with ISO-ECHO, "ON." These settings provide maximum sensitivity for cloud detection. Even so, the TPQ–11 does not detect small, fair weather cumulus unless the cloud contains droplets that have grown to precipitation size. Table 9 shows recommended control settings during specific weather conditions. The TPQ–11 can provide much information that you, the observer, do not need for your observation. The control settings in table 9 permit the TPQ–11 to operate at its peak sensitivity for obtaining maximum data. Although the TPQ–11 radar provides more information, your primary concern is to obtain bases and tops of cloud layers from the radar cloud detector (RCD). The following discussion centers on some TPQ–11 peculiarities relative to that responsibility.

7-19. The TPQ–11 does not measure precise boundaries of clouds or moisture. The sensitivity of the set depends upon the concentration, number, and the diameter of the energy scatterers. If these two factors cannot cause enough energy to be returned to the set, the cloud or moisture is undetected by the TPQ–11. You must visually evaluate the sky cover before relying on radarscope presentations. The TPQ–11 performs a reliable measurement of nonprecipitating cloud bases particularly if it is a water-bearing cloud. Sharply defined cloud bases are also reliable. On the other hand, scope display of cloud bases during precipitation and bases that are fuzzy or ill defined should not be considered as completely reliable. In these cases, the true cloud base is obscured by returning signals from the precipitation or virga.

7-20. Cloud top measurement is reliable under practically all conditions except intense precipitation (exceeding 0.75 inch/hour). During intense precipitation, height measurement is inaccurate because of the signal attenuation near the surface caused by the heavy precipitation. At times, cloud tops appear on the recorder as vertical towers or columns rising above a common level. This indicates turbulence, and the towers may be convective cloud buildups breaking through the top of a thick cloud layer. Some cloud tops are masked by precipitation falling from a higher cloud layer. When this happens, the TPQ–11 shows what appears to be a thick cloud layer even when in reality there are two separate layers. However, if the TPQ–11 shows a clear zone between layers, you can be sure the clear zone exists.

7-21. A phenomenon frequently observed but difficult to explain is the appearance of random signal returns. These random returns are called "angels" perhaps because there is no visible evidence to support their existence even though the TPQ–11 "sees" them. One explanation for them is the existence of small but pronounced discontinuities of moisture. Whatever their cause, do not mistake angles for clouds when they appear on the scope. Angels sometimes appear as a dense return, or they appear as isolated, vertical lines on the recorder chart. You can recognize them on the scope because they appear as momentary blips rather than as a persistent return that indicates the presence of clouds. Angel activity is more pronounced in warm temperatures and high humidity and especially when conditions are favorable for convection. In summary, the TPQ–11 radar cloud detection set helps you to determine cloud base and top heights. However, the information received is not always reliable. Consequently, you must interpret the data presented on the indicator.

7-22. **Visibility Measuring Equipment.** Standard items of visibility measuring equipment are the Transmissometer, AN/GMQ–10, and the Runway Visual Range Computer, AN/FMN–1. The transmissometer operates on the principle of a beam of

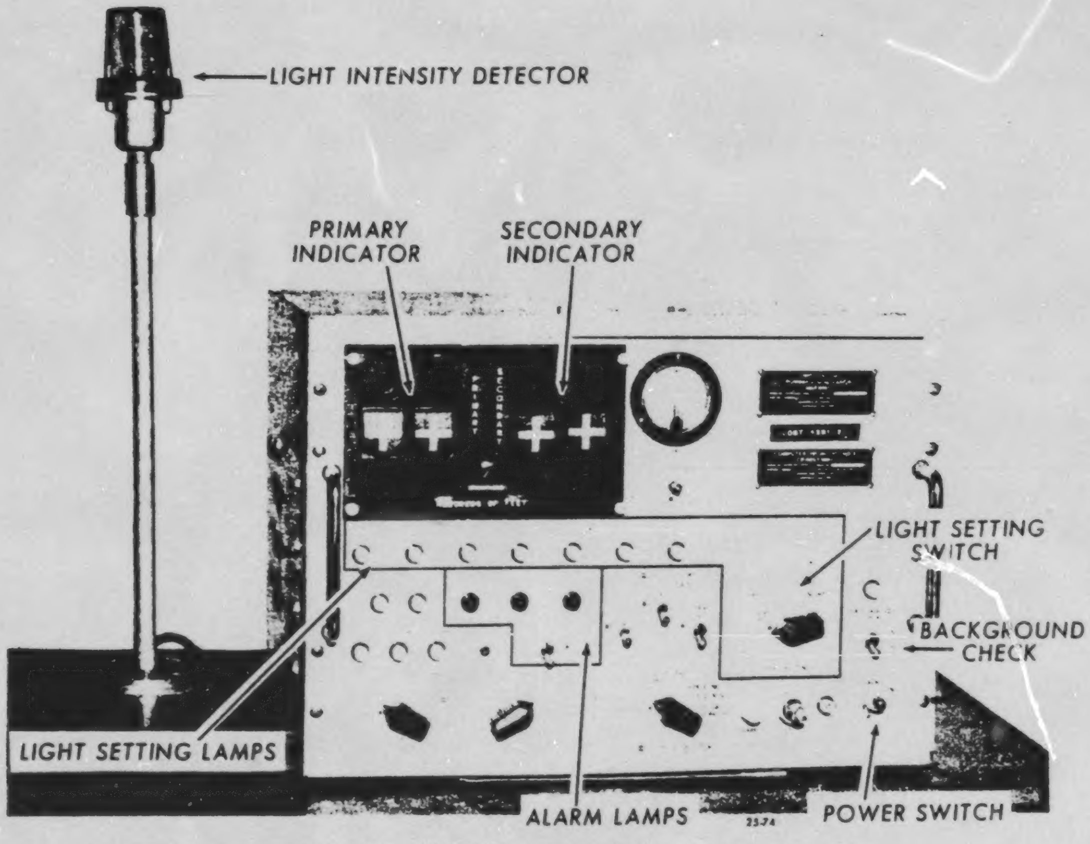


Figure 25. AN/FMN–1 runway visual range computer.

light directed at a light-sensitive photocell. This photocell is sensitive to the amount of light that it receives and, therefore, registers any reduction in the amount of this light. An obstruction, such as rain, fog, or haze between the projector and the photocell reduces the amount of light that the photocell receives. The percentage of reduction (transmissivity) is converted by tables into linear visibility values. The transmissometer primarily supplies a visibility value useful to the pilot rather than a general value of how far one can see in all directions. Recall from figure 20 that the GMQ–10, Transmissometer, was placed alongside the runway in order to measure that specific visibility.

7-23. Commonly, the FMN–1 computer operates in conjunction with the transmissometer. The output pulses from the transmissometer receiver, which are proportional to visibility, provide the input information for the computer. The FMN–1 does not replace or supplement the GMQ–10. Using the same electrical data, the computer simply displays a different visibility measure. The computer subtracts background illumination and displays the resulting runway visual range in hundreds of feet. A current visibility value is computed every 51 seconds (called the 1-minute mean) as is the average of each group of ten 51-second values (the 10-minute mean). The 1-minute mean is displayed on the primary indicator and the 10-minute mean on the secondary indicator, figure 25. Turn on the computing set when the visibility is reduced to 2 miles or less, or is expected to be reduced to 2 miles within 3 hours. The computer may be turned off if these conditions (or a local need) do not exist.

7-24. Obtaining routine visibility from the measuring equipment normally poses no observational problems. If you are measuring with the FMN–1 computer, it makes an automatic background check when first turned on. Manual background checks can be taken by depressing the background switch, figure 25, whenever you think it is necessary. The computer stores and uses the last background check taken. If the active runway or visibility sensing devices are switched, you may take a new background check for the runway in use. However, if you do this, the computed 1-minute mean is unreliable for 3 minutes, and the 10-minute mean for about 11½ minutes. The 11½-minute period allows the computer to make a new background check (taking about three minutes) and a new 10-minute mean count (taking 8½ minutes).

7-25. A change in runway light setting may also render the current readout values on the computer invalid. A new 1-minute readout appears in 51 seconds, but the 10-minute readout takes 8½ minutes to average 10 new values. The computer has a light-setting switch that you use to select the light setting for which you want the computer to compute values. This switch does not set the runway light intensity; it only affects the computing function of the set. The light-setting lamps indicate the runway light setting that is in use. If you want the runway visibility based on the current light setting, position the light-setting switch to a setting identical with the illuminated light-setting lamp. Both light-setting switch and lamps are pointed out in figure 25. Figure 25 also shows the light intensity detector which automatically decides between day and night illumination, and selects the proper computer function.

7-26. Stations normally reporting runway visual range rely on the FMN–1 for data. Transmissometer operation is minimized. When the transmissiometer is the primary measuring instrument, obtaining runway visibility requires you to take some simple precautions. Always correct the observed reading for background illumination. Do this before converting the reading to visibility from the prepared conversion tables.

7-27. Occasionally you must also check the zero reading of the GMQ–10. This test will show the need for a "zero" adjustment by the technician. Background and zero checks are the only two equipment checks you need to make. In addition to these two checks, you may operate the transmissometer in two modes. At low transmission readings, less than 15 percent, the GMQ–10 offers an expanded scale feature. Place the transmissometer range switch in HIGH mode when transmissivity is less than 15 percent. This action simply multiplies by five the value indicated by the pen. A 10 percent value in LOW range becomes a 50 percent value in HIGH range. The important point about HIGH mode is to divide the indicated value by five before converting to a reportable runway visibility. Changing the range switch to HIGH does not increase the sensitivity of the set. The same amount of projected and detected light applies to either mode. Your chances for accurately reading the low scale values improve with the expanded scale.

7-28. Each transmissometer recorder chart must display as minimum identification the following entries:

a. Station name, time check, date-time group (LST), runway number, and length of transmissometer baseline, both at the beginning and ending of the chart.

b. Time check and date-time group (LST) at the actual time of each 6-hourly observation.

Besides these two notations, enter time checks and date-time groups for the beginning and ending of maintenance shutdowns or other periods of inoperation, and notification of any aircraft mishap occurring either at or within the vicinity of your station. If the chart time differs from correct time by 5 minutes or more, adjust the chart and enter a new time check on the chart.

7-29. **Precipitation Gage.** The standard rain gage (fig. 26) in use at Air Weather Service detachments is a very simple collection device. It collects precipitation for measurement, whether the precipitation falls in liquid or solid form. Despite certain limitations of collection under gusty and high wind conditions, the gage provides a fairly representative assessment of the amount of precipitation that falls between specified measurement times.

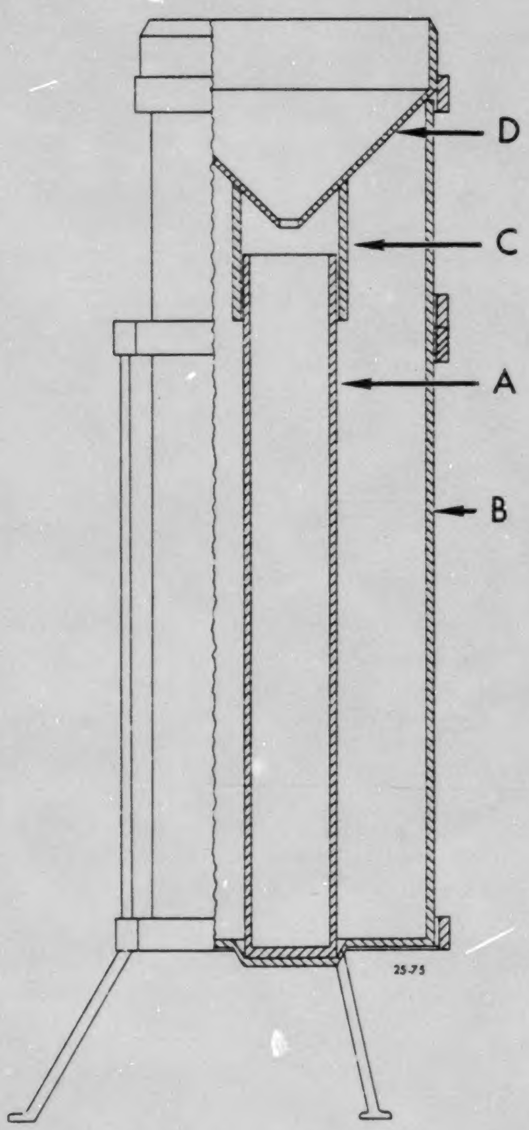


Figure 26. Rain gage.

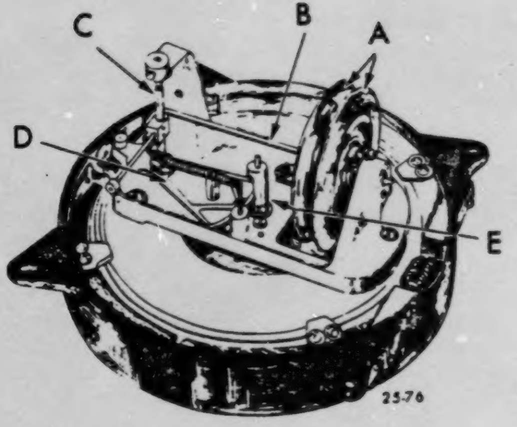


Figure 27. Aneroid barometer mechanism.

7-30. In figure 26, the measuring tube (A) is held in an upright position within the overflow can (B) by the sleeve (C) that is attached to the collector-funnel unit (D). The collector-funnel unit directs the precipitation into the measuring tube beneath it. Another sleeve fits over the mouth of the overflow can and holds the funnel in place. When completely filled, the liquid in the measuring tube represents 2 inches of liquid precipitation.

7-31. Liquid precipitation is measured by a 24-inch measuring stick that is graduated in hundredths of an inch and labeled every tenth of an inch. The measuring stick is made of redwood, which has a slow absorption rate. The stick turns very dark when it is wet, making it easy to read.

7-32. Insert the dry measuring stick into the measuring tube. Withdraw the stick after 2 or 3 seconds and read the precipitation depth to the nearest 0.01 inch at the upper limit of the wet portion of the stick. When the tube is completely full, empty the contents and then measure the overflow by pouring it into the tube. This excess, plus the original 2 inches of liquid in the tube, is the total precipitation amount for the observation period.

7-33. When solid precipitation is expected, remove the collector-funnel unit and the measuring tube from the overflow can to facilitate collection. Since you are interested in determining water equivalents of solid precipitation, melt the contents of the can before measuring the fallen amount. Pour a measured amount of warm water into the can and then pour the resulting liquid into the measuring tube. After measuring the total liquid, remember to subtract the amount of warm water used to melt the solid precipitation. The difference is the water equivalent of the solid precipitation.

7-34. During snowfall accompanied by strong or gusty winds, the amount of fall collected in the overflow container may not represent actual snowfall. Discard the gage measurement if you think a more representative measurement can be obtained by vertical core sampling on the ground. To take a core sample, select a smooth, level, grassy area of ground and take several samples. Lay snowboards, 2-foot square pieces of light-colored board, to separate different periods of snowfall.

7-35. **Pressure Instruments.** Mercury barometers measure pressure by means of a calibrated, known height of a mercury column. Because of its accuracy, the mercury barometer acts as the calibration standard for other types of barometers. Aneroid barometers measure pressure by the contraction and expansion of a bellows type vacuum cell. When properly calibrated, the aneroid barometer is highly accurate also, and since its measuring scale is easier to read than the mercurial scale, the aneroid barometer is used for routine hourly pressure measurements. The barograph is basically an aneroid barometer, but it also makes a continuous record of the pressure on a rotating chart called the barogram. Even though the mercury barometer is more precise, the priority for barometer usage is the aneroid barometer, microbarograph,

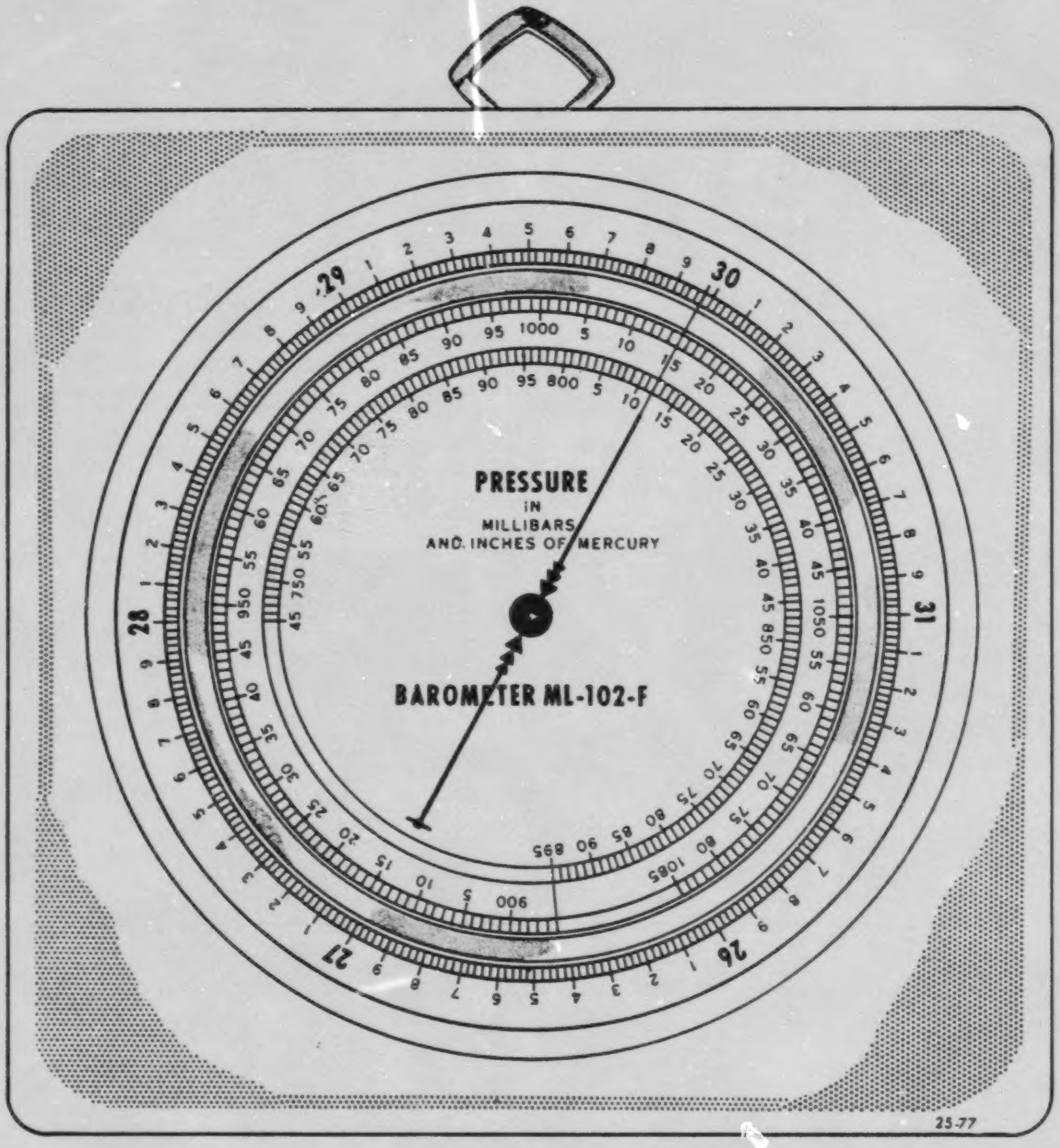


Figure 28. Aneroid barometer scale.

aircraft-type altimeter, and mercury barometer. In the discussion that follows, you learn how pressure instruments operate and how to read them.

7-36. *Aneroid barometer*. The aneroid barometer, as shown in figure 27, consists essentially of an aneroid cell, often called a bellows (A), from which air and water vapor have been removed and a minute amount of dry, inert gas introduced. The bellows is sensitive to changes in pressure and expands or contracts as the pressure decreases or increases respectively. The amount of change in the bellows is then magnified mechanically through a linkage (B) and gear system (D) to operate the pointer (E) on the face of the barometer. The reliability of the aneroid barometer depends upon the strength, flexibility, and resilience of the metal used for the aneroid cell and its consistency of performance under varying conditions of pressure and temperature.

7-37. An increase in temperature causes the metals of the aneroid cell and the spring, if any, to offer less resistance to compression and causes thermal expansion of the parts. If these effects are uncorrected, the indicator of the aneroid barometer varies with both pressure and temperature. Two methods are usually combined to overcome most of the effects of temperature. One is to introduce a small amount of inert gas in the aneroid cell as it is sealed, so that as temperature rises the pressure of the inert gas increases to help compensate for the weakening of the force of the spring action. The other method is to use a bimetal temperature compensation shaft (fig. 27,C) built into the mechanical apparatus, so that as temperature rises, the difference in expansion of the two metals causes the shaft to bend slightly. Because of the function of the shaft in the mechanism, this bending produces a slight shift in the indication of the pointer. You can see that it is necessary to place the aneroid barometer where there is no vibration and where the temperature is as constant as possible to obtain the most accurate pressure readings. Even so, you must compare the aneroid barometer reading with the mercurial barometer reading two times, at 6-hour intervals, on the same day of the week. You use each weekly comparison to compute the average correction applied to aneroid barometer readings until the next comparison. The tolerance for the comparison reading is ±0.01 inch or ±0.3 millibar.

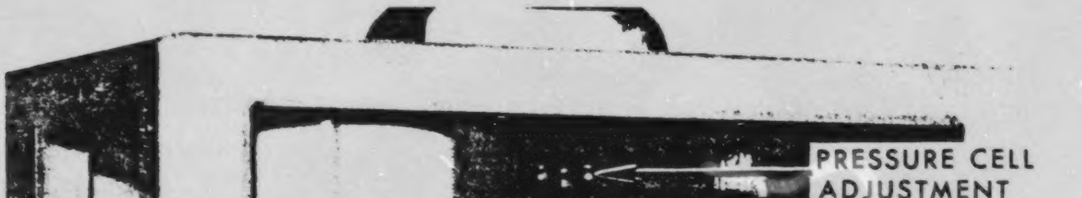


Figure 29. Microbarograph ML-563/UM.

7-38. The aneroid barometer scale is generally graduated in inches, tenths, and two one-hundredths; however, the scale graduations are large enough to accurately determine the pressure to the nearest 0.005 inch, as required. There is a definite procedure for reading the aneroid barometer just as there is for the mercurial barometer. First, tap the face of the instrument lightly with your finger to reduce the effect of friction. Read the indication to the nearest 0.005 inch, or if calibrated in millibars, to the nearest 0.1 millibar. Estimate values between the scale graduations. Figure 28 illustrates a reading of 29.980. To read the pressure accurately, adjust your line of sight so that the pointer and its image in the silver ring are aligned. When you have determined the correct reading, you must apply the instrument correction, as determined from AWS Form 85, Test, Barometer Comparisons, to determine actual station pressure.

7-39. *Microbarograph*. A microbarograph is a recording aneroid barometer that has a pen to make a trace of pressure variations on a chart that has a magnified scale. The barograph shown in figure 29 is the type most often found in Air Weather Service stations. On this barograph, the chart shows a 1-inch pressure change over a vertical distance of 2.5 inches. This is known as a 2.5:1 ratio of pressure change magnification.

7-40. The barograph has two bellows that respond to pressure by expanding and contracting. These responses pass through a linkage that magnifies the movement and ends in a pen arm and pen. The pen in turn makes an ink trace on the barogram. The barogram is mounted on a vertical cylinder, driven by a clockwork mechanism (8 day) so that the drum rotates at a uniform rate, usually 1 revolution every 4 days.

7-41. Again, as in aneroid barometers, temperature variations can cause barograph errors. The error is compensated for in the same way as in the aneroid barometers. Additionally, barographs are equipped with either dashpots or a damper to damp out the effects of vibrations and small-scale pressure fluctuations. The damper can be adjusted when the pen of the barograph shows excessive vibration. Also, just as the aneroid barometer, the barograph is not an absolute instrument; therefore, it must be set (when used as the primary instrument), using the mercurial barometer as the station standard.

7-42. You must set the barograph to the correct pressure when you change the chart. The chart is divided into inches, tenths, and two one-hundredths inch of pressure, just like the aneroid barometer. You, however, must read the microbarograph to the nearest 0.005 of an inch to satisfy the requirements for station pressure. It is also divided into hours so that the pen trace can be set for a certain time of day. Set the pressure to the nearest 0.01 inch by adjusting the knurled knob atop the pressure-cell housing. Set the time by turning the chart cylinder counterclockwise until the penpoint indicates the proper time on the time divisions of the chart. Although the barograph chart is printed with a 4-day time scale, Air Weather Service units use it for 8 days by obtaining a second 4-day trace on each chart. Enter the beginning date of the trace on the chart.

7-43. *Mercurial barometer*. The mercurial barometer ML–2 consists of a glass tube approximately 36 inches long with a ¼-inch internal diameter. The top of the glass tube is sealed, and the bottom end opens into a reservoir called the cistern. During manufacture, the tube is filled with mercury and inverted in the cistern. As the mercury drains from the tube into the cistern, an almost perfect vacuum is created in the top of the tube. The vacuum is necessary so that, as the atmospheric pressure outside the tube changes, the mercury in the tube can move up and down without a back pressure from air trapped inside the tube. Unfortunately, however, it is very difficult to fill a barometer tube without trapping small amounts of air, water, and mercury vapor in the space above the mercury. Therefore, an instrumental correction is computed and applied to all mercurial barometer readings to compensate for this defect.

7-44. Despite careful attempts to construct a precision instrument, certain unavoidable instrument errors occur. Briefly, these errors require correction for:

a. Inaccurate zero setting or scale calibration.
b. Capillarity (frictional effect between the mercury and the glass tube).
c. Imperfect vacuum (in the top of the glass tube).

The instrumental error for a barometer is determined and entered on DD Form 744 at the manufacturer's laboratory. The form accompanies the barometer to its point of installation where more corrections are needed to fit the barometer to its geographic location. These corrections compensate for errors caused by:

(1) Gravity and altitude above sea level.

(2) Removal (the vertical distance between the elevation of the ivory point and station elevation).

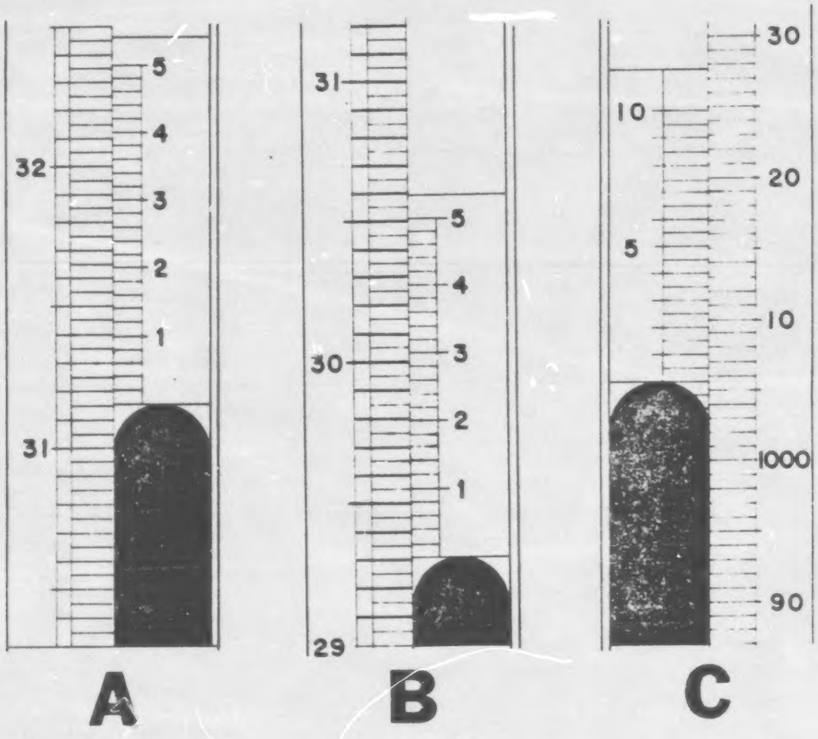
(3) Instrumental residual errors (caused by environmental differences between laboratory and site).

All of the instrument and location corrections are entered on DD 744 and, when totaled, make up the Sum of Corrections.

7-45. Before you take an observation of the station pressure, you must determine the temperature of the air surrounding the barometer. Use this temperature value, obtained from the attached thermometer, to compute the temperature correction. After you determine the temperature, adjust the mercury in the cistern. Always lower the mercury in the cistern, by means of the cistern adjusting screw, to a short distance below the ivory point. Next, adjust the mercury level up to approximately 1/16 inch below the ivory point and gently tap the metal cistern and the brass casing near the top of the mercury column. This helps to overcome the friction between the mercury and the glass. It also helps the mercury to assume its proper shape. Again adjust the mercury level until it just touches the ivory point, and the background light just disappears between the point and the mercury surface. When the setting is correct, there should not be even a slight dimple where the ivory point makes contact with the mercury surface. If the mercury surface is bright and the setting correct, the tip of the ivory point appears to coincide with its reflected image on the mercury surface.

7-46. The next step is to adjust the vernier near the top of the mercury column (the meniscus). Again tap the metal casing near the meniscus so that it assumes its normal rounded shape. Raise the vernier above the meniscus and lower it very slowly to near the top of the mercury column. Stand so that your eye is on a horizontal line of sight to the top of the mercury column. Slowly adjust the vernier downward with the knurled knob until the lower edge lies on top of the mercury column, as shown in figure 30.

7-47. To read the height of the mercury column, you must understand the scales attached to the barometer. Generally, the mercurial barometer is read in inches to the nearest 0.001 inch; however, some stations use a millibar scale that is read to the nearest 0.01 millibar. Our discussion centers on the inch scale. The permanent scales on the ba-



	A	B	C
SCALE-VERNIER RATIO	24:25	24:25	19:20
SMALLEST INTERVAL	.002 in	.002 in	.05 mb
SCALE READING	31.150	29.300	1005.00
VERNIER INCREMENT	.006	.017	.65
BAROMETER READING	31.156	29.317	1005.65

25-79

Figure 30. Mercurial barometer scale readings.

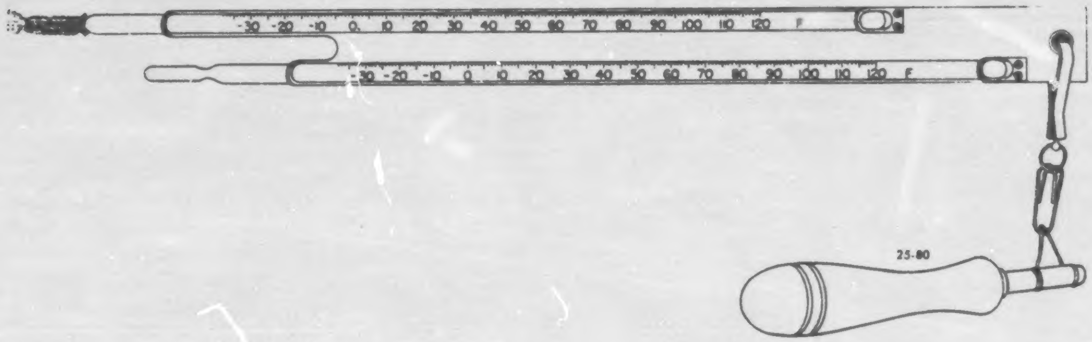

-30 -20 -10 0 10 20 30 40 50 60 70 80 90 100 110 120 F
-30 -20 -10 0 10 20 30 40 50 60 70 80 90 100 110 120 F
25-80

Figure 31. Sling psychrometer.

rometer are graduated in inches, tenths, and five one-hundredths. The vernier scale is graduated to 0.002 of an inch. Take the first portion of the reading from the fixed scale directly opposite the index (the bottom line or top of the meniscus) of the vernier. In the inch scale shown in figure 30,A, the index shows a reading on the fixed scale between 31.15 and 31.20 inches. From the fixed scale, always read the value of the line nearest to, but still below, the index; in this case, 31.15 inches. Having read the fixed scale, proceed to check for one of two conditions to read the value from the vernier.

7-48. One condition is the presence of a line on the vernier directly opposite a line on the fixed scale. If this is so, read the value of hundredths and two one-thousandths of an inch to be added to the fixed scale reading. As shown in figure 30,A, the value is 0.006 inch, and the barometer reading is 31.156 inches.

7-49. The second condition is the absence of a line on the vernier aligned with a line on the fixed scale. This is shown in figure 30,B. In this case, two lines on the vernier are between two lines on the fixed scale; this is the point that you must evaluate. This condition produces a value of hundredths and one one-thousandths of an inch to add to the fixed scale reading. In figure 30,B, the scale reading is 29.30 inches; the vernier reading is between the third and fourth graduations that are between the numbers 1 and 2 (0.01 and 0.02). The vernier value is 0.017 inch, which, when added to the scale value of 29.30, gives a barometer reading of 29.317 inches. Figure 30,C, shows a millibar scale, and the scale reading plus the vernier reading results in a barometer reading of 1005.65 millibars. The scale-vernier ratios shown in figure 30 denote the ratio of scale divisions to the vernier divisions.

7-50. If you should find anything unusual with either of these barometers or the barograph, inform the weather equipment technician. The intermediate maintenance representative is responsible for mechanical and calibration adjustments. Calibration comparisons of the mercurial barometer are made from a master mercurial barometer, ML-330/FM, by the intermediate maintenance shop. The master barometer is certified at regular intervals by the base Precision Measuring Equipment Laboratory (PMEL).

7-51. **Temperature-Humidity Measuring Instruments.** There are several types of thermometers, classified according to their construction. Liquid-in-glass thermometers contain either mercury or alcohol. Mercurial thermometers are used in the Temperate and Tropical Zones. The general-purpose mercurial thermometer has a temperature range of −35° F. to +125° F. There is also a mercurial thermometer with a tropical temperature range of +10° F. to +145° F. Since mercury has a freezing point of approximately −39° F., the alcohol thermometer is used in Arctic regions. The use of alcohol was adopted because of its low freezing point. Arctic thermometers have a temperature range of −90° F. to +90° F. There are also electrical thermometers. These thermometers work on the principle that a change in temperature causes a change in electrical current by using either a thermocouple or thermistor. This section discusses obtaining temperature from the psychrometer and operation of the TMQ–11, Humidity-Temperature Set.

7-52. *Psychrometer.* The psychrometer consists of a metal backplate with two liquid-in-glass thermometer tubes fastened to it so that the mercury bulb of one tube extends approximately 2 inches beyond the bulbtip of the other tube. This thermometer, the wet-bulb thermometer, is extended so that you can dip it in water without moistening the dry-bulb thermometer. Figure 31 is an illustration of the sling psychrometer, showing the position of the thermometer tubes. At the upper left, notice the wick tied to the end of the wet-bulb thermometer.

7-53. There are several ways to mount the psychrometer and to ventilate the wet bulb. Within the instrument shelter, you can hang the psychrometer in front of a handcranked fan, fasten it to a crank that whirls the psychrometer, fasten the backplate to a clamp that holds the psychrometer in front of the intake of a motor-driven aspirator, or, more simply, use the psychrometer with the sling shown in figure 31.

7-54. No matter what method you use, there are certain procedures you must follow in moistening the wet bulb and ventilating the psychrometer. Two temperatures are obtained from the psychrometer–the dry-bulb temperature (free air) and the wet-bulb temperature (temperatures reached by evaporational cooling).

7-55. Moisten the wet-bulb muslin with clean water just before ventilating, even though it appears wet when the humidity is high. When the temperature is high and the relative humidity is low, moisten the wet bulb several minutes before taking the reading. Make sure that the wick is saturated and a small drop of water forms on the end of the bulb. This prevents the wet bulb from drying out before the temperature reaches its lowest value. In extremely dry areas (desert, semidesert, etc.), precool the water. Store the water in a porous jug for this purpose, but do not keep the water in the instrument shelter, since this alters the moisture conditions within the shelter. When this procedure is not completely effective, do the following: Replace the regular muslin wick with one that extends several inches below the tip of the thermometer bulb so that the wick extension can be immersed in water. Before ventilating the wet-bulb thermometer, remove the wick from the water until you obtain the wet-bulb temperature.

7-56. When the dry-bulb temperature is 37° F. or below, use water that has been kept at room temperature to completely remove any accumulation of ice (frost) from the wick on the wet-bulb thermometer. Moisten the wick thoroughly, at least 15 minutes prior to ventilating, to permit the dissipation of latent heat. Do not allow excess water to remain on the wick, since a thin, thoroughly cooled coating of ice is necessary for accurate wet-bulb temperatures at 37° F. or below (free air temperature).

7-57. When you expect that the wet-bulb temperature will be 32° F. or less, moisten the wick a few minutes before taking the reading and allow some natural evaporation to occur. This aids in reaching a wet-bulb temperature that is near freezing, and when the bulb is ventilated, freezing is facilitated. If ice does not form, touch the wick with ice, snow, or some cold object to aid in forming the ice. Continue to ventilate, and take the reading when the wet-bulb temperature reaches its lowest value.

7-58. After properly moistening the wet bulb according to existing conditions, ventilate the psychrometer. To insure proper ventilation, the air should pass over the psychrometer bulbs at a minimum speed of 15 feet per second. The psychrometer aspirator ML–480/GM, a motor-driven fan used at Air Force stations, provides the proper ventilation. If you use the sling psychrometer, swing the instrument so that it revolves at two revolutions per second. When you use the crank-driven fan or the direct-drive rotor, turn the crank at a speed of 3½ revolutions per second, and when you use the geared crank, turn it at approximately one revolution per second.

7-59. Ventilate the instrument for about 10 seconds and then quickly read the wet-bulb temperature. Repeat this procedure until two successive wet-bulb readings are the same. This indicates that the wet-bulb temperature has reached its lowest point. If the wet-bulb temperature rises between successive readings, remoisten the wick and ventilate the thermometers again. Accurate reading is especially important at low temperatures, since a given wet-bulb depression has a greater effect at lower temperatures on the accuracy of humidity computations.

7-60. When you use the sling psychrometer, certain special precautions must be observed. You must whirl the psychrometer in a space that is clear of obstructions and in as much shade as possible. At times, the only shade available is that of the shelter and your body; however, whirl the psychrometer as far from your body as possible so that body heat does not affect the readings. If at all possible, face into the wind. Proper ventilation of the sling psychrometer is illustrated in figure 32, using the body and the shelter as shade and whirling the instrument while holding it away from the body.

7-61. In reading the thermometers, there are a few precautions that you must observe. First, stand as far away from the thermometer as is consistent with accurate reading to prevent your body heat from affecting the reading. Second, make certain that your line of sight is perpendicular to the thermometer tube at the top of the liquid column, as shown in figure 33. This avoids introducing an error of parallax. Read the thermometer to the nearest 0.1°. Make sure that the proper tens values are used for the temperature reading.

7-62. At many Air Weather Service detachments, where the automatic Humidity-Temperature Set, AN/TMQ–11, is installed, the instrument shelter has been removed. (The AN/TMQ–11 will be discussed later.) Where

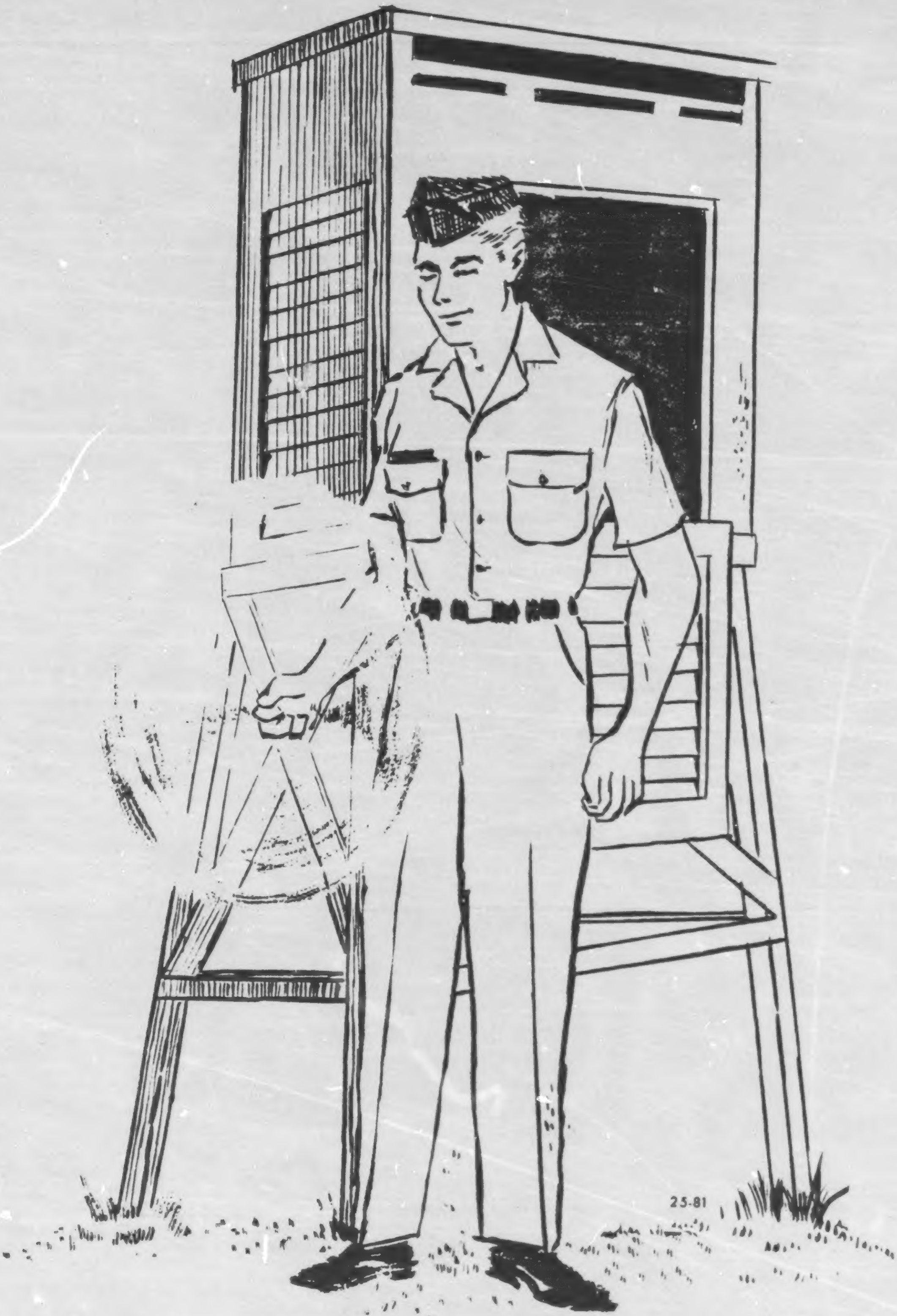


Figure 32. Ventilating a sling psychrometer.

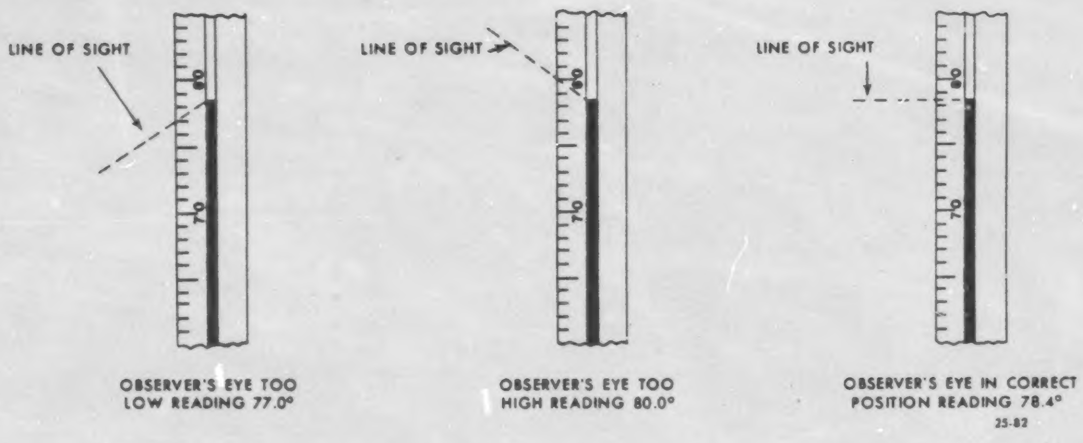

LINE OF SIGHT
80
70
OBSERVER'S EYE TOO LOW READING 77.0°
LINE OF SIGHT
80
70
OBSERVER'S EYE TOO HIGH READING 80.0°
LINE OF SIGHT
80
70
OBSERVER'S EYE IN CORRECT POSITION READING 78.4°
25-82

Figure 33. Reading the thermometer.

there is no instrument shelter, the psychrometer is kept in the observation site. When it is necessary to use the sling psychrometer to verify that the TMQ–11 is operating properly or to use it for temperature readings when the automatic unit is inoperative, the psychrometer must be taken from the office and exposed to the outside free air for a period of time to obtain the proper indications.

7-63. *Humidity-Temperature Set, AN/TMQ–11.* Most commonly used at fixed site observing stations, is the AN/TMK–11, Humidity Temperature Set, a type of electrical thermometer. Often the TMQ–11 is referred to as a hygrothermometer because it also measures dewpoint temperature that gives an indication of humidity. The humidity-temperature set operates continuously, 24 hours a day. Read all temperatures to the nearest degree. Degrees correspond to the center of degree markings of each indicator; that is, the middle of the degree marks and not the edges or spaces between them. Obtain temperature and dewpoint readings from the standby system when the TMQ–11, used as the standard, exceeds 1° F. error in dry bulb or 2° F. in dewpoint.

7-64. Occasionally, the dewpoint indicator registers the same or a higher temperature than the ambient (free air) temperature, especially during fog or precipitation. In this case, if no equipment error is suspected, consider the dewpoint to be the same as the temperature unless ice fog is present. Under ice fog conditions, assume that the dewpoint with respect to ice is the same as the temperature, and convert the dewpoint from ice to water.

7-65. **Wind Measuring Set.** Two sets, AN/GMQ–20 and AN/GMQ–11, provide fixed-station surface wind measuring and indicating. Wind sets are oriented to magnetic north. A recorder may be used with the GMQ–11 and the GMQ–20 comes supplied with one. The GMQ–20 offers one important advantage over the GMQ–11; it can accommodate many more readouts (indicators or recorders). These wind measuring sets can measure windspeeds up to 240 knots on the recorder. Indicator range is from 0 to 120 knots. To record speeds over 120 knots, you must switch the recorder to high range. Obtaining windspeed or direction from the indicator or recorder is not difficult, as you know. You must remember to convert magnetic to true direction before longline dissemination. Figure 34 shows the GMQ–11 indicator and RO–2 recorder.

7-66. Operation of the GMQ–11 requires very little of your effort. Operate the set in the 0- to 120-knot low range. Recorder chart speed is normally 3 inches per hour, but it can be changed to 6 inches per hour to give a clearer record of changes in speed or direction. This conversion of chart speed is done by an equipment technician only. When you change the chart roll, enter the station name, date, and time that the record began at the beginning of each roll. Also, enter the station name, date, and time that the record ended at the end of each roll. After the chart is changed and the time is set, enter a time check at each 6-hourly observation by drawing a short line and entering the date and local time on the chart. You must change charts at 0000 LST (Local Standard Time) on the first day of each month. This is a mandatory requirement. When the recorder becomes more than 5 minutes in error, adjust the chart to the correct time, and indicate the adjustment by means of an arrow and note the time of adjustment. If the chart feed rate is changed, indicate this by a short line and a notation such as "Begin 3 in/hr."

7-67. Wind measuring sets are easy to operate compared to the operation of the radar storm de-

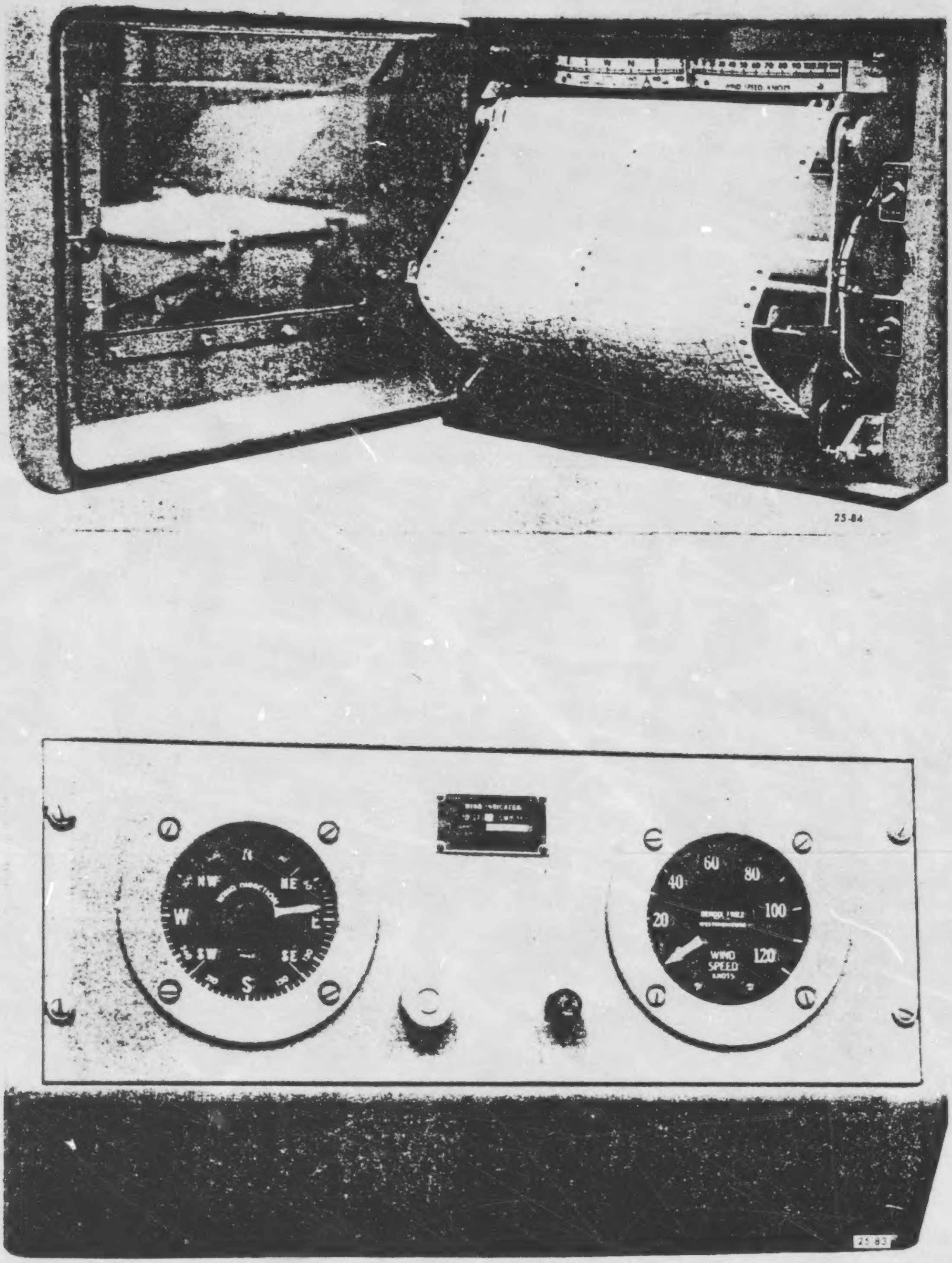
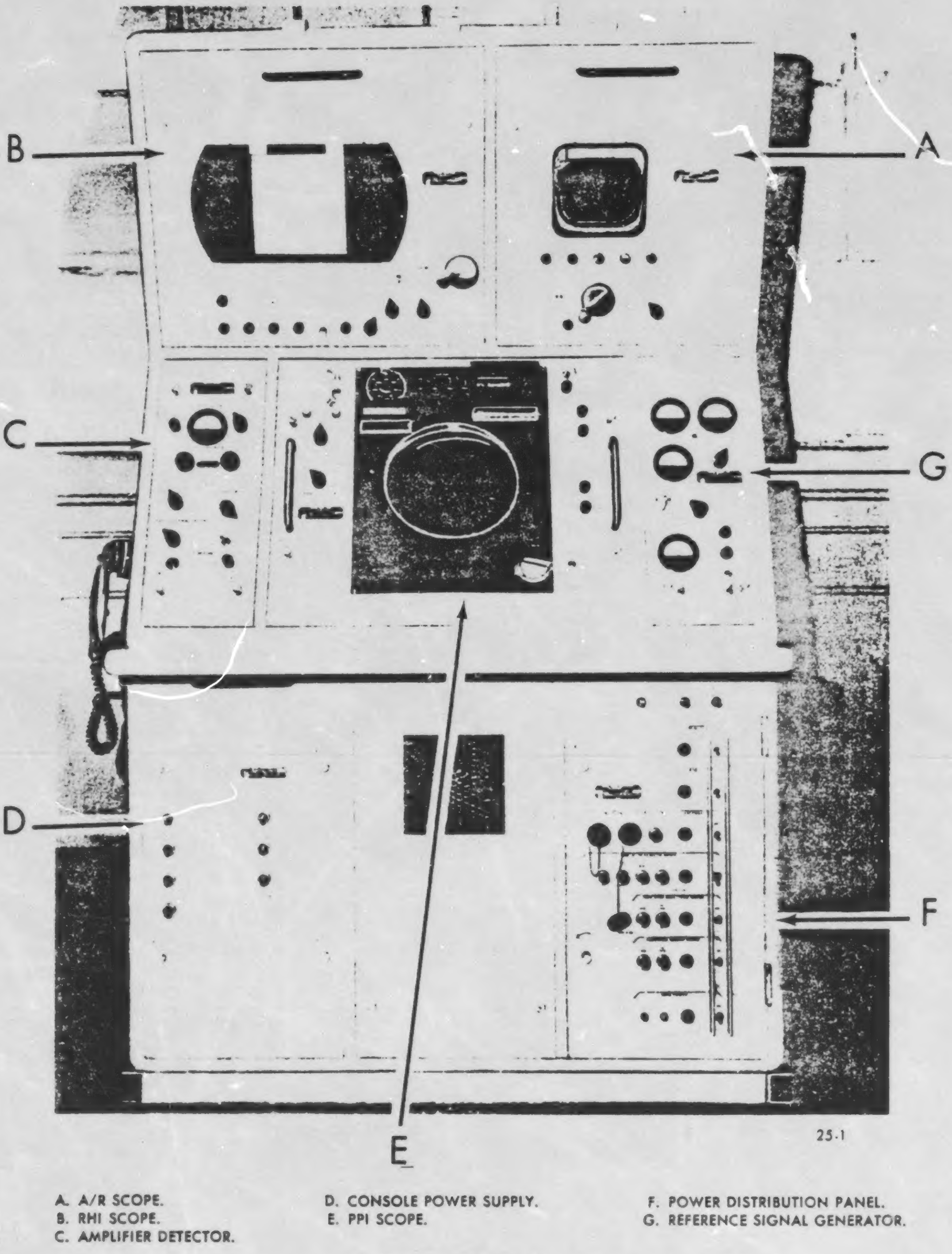

WIND SPEED KNOTS
25-84
WIND DIRECTION
N
NW
NE
W
E
SW
SE
S
20
40
60
80
100
120
WIND
SPEED
KNOTS
25-83

Figure 34. AN/GMQ-11 wind indicator and RO-2 recorder (TOP).



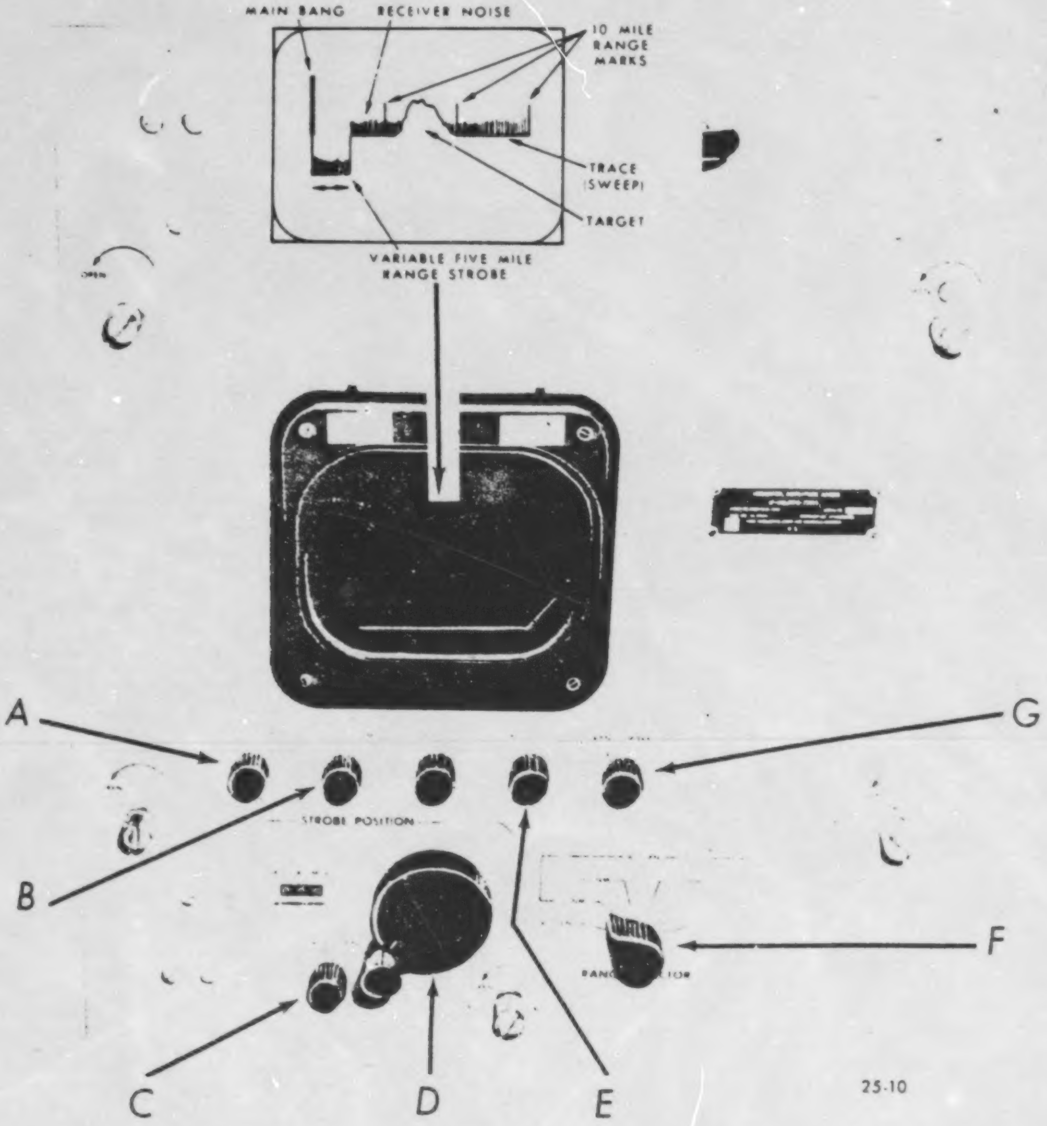
A. A/R SCOPE.
B. RHI SCOPE.
C. AMPLIFIER DETECTOR.
D. CONSOLE POWER SUPPLY.
E. PPI SCOPE.
F. POWER DISTRIBUTION PANEL.
G. REFERENCE SIGNAL GENERATOR.

Figure 35. AN/FPS-77 console.

tection set discussed in the next section. Refer now to your workbook and answer the chapter review exercises for Section 7.

8. Storm Detection Radar

8-1. The AN/FPS–77 is a radar set designed specifically to detect meteorological phenomena. Radar uses the same principles of operation as radio. In fact, *radar* is the acronym for *RA*dio *D*etection *A*nd *R*anging. The fact that short pulses of high-frequency radio waves reflect from objects that they strike makes radar possible. Today's weather radar detects precipitation, water droplets, ice crystals, or snowflakes since these reflect the transmitted radar energy. The wavelength of the transmitted radar signal is a critical feature that determines the sensitivity of the weather radar relative to droplet size. Shorter wavelengths detect smaller droplets. Since the FPS–77 is designed as a storm detection radar, it operates at a longer


MAIN BANG
RECEIVER NOISE
10 MILE RANGE MARKS
TRACE (SWEEP)
TARGET
VARIABLE FIVE MILE RANGE STROBE
A
G
STROBE POSITION
B
F
C
D
E
25-10

A. VIDEO GAIN CONTROL.
B. ASTIGMATISM CONTROL.
C ASTROBE GAIN CONTROL.
D. STROBE POSITIONING HANDWHEEL.
E INTENSITY CONTROL.
F. RANGE SELECTOR SWITCH.
G RANGEMARK GAIN CONTROL.

Figure 36. A/R scope and presentation.

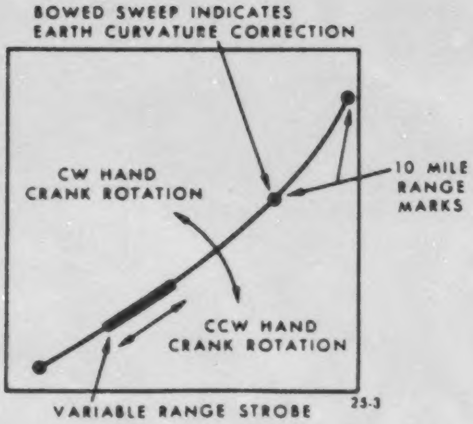


Figure 37. RHI scope presentation.

wavelength (5.4 centimeters) than earlier weather radar sets. This longer wavelength allows the set to detect storm cells and to have less attenuation from precipitation. This following discussion of radar includes the types of scopes, the operational features, radar terms, techniques of scope interpretation, and care of the set.

8-2. **Radarscopes.** Three types of scopes are used on FPS–77 radars. Each scope presents a different radar view of the echo. Also, a remote PPI (plan position indicator) scope is available. Figure 35 shows the FPS–77 console. The PPI scope (E) is located in the center of the console, with the controls located on the scope panel. The RHI (range and height indicator) (B) and the A/R (azimuth and range) (A) scopes are located above the PPI scope on the upper panels. The amplifier detector (C), console power supply (D), power distribution panel (F), and the reference signal generator (G), are discussed later in the text.

8-3. **Azimuth and range (A/R).** Figure 36 shows the A/R scope which displays the *range* and *relative* intensity of weather targets. The video gain control (A), astigmatism control (B), strobe gain control (C), strobe positioning handwheel (D), intensity control (E), range selector switch (F), and range marks gain control (G) are all functions of controlling the target picture for maximum interpretation of the target; as you progress with your on-the-job training your trainer will teach you proper use of each control. On this scope, the sweep travels across the face of the tube from left to right in a straight line, (trace sweep) figure 36. When an echo is received, a "blip" appears and extends above the sweep, as shown in figure 36 (target). With the set operating in range normalization mode, the height of the blip is proportional to the intensity of the echo—the higher the "blip," the stronger the echo. This scope also shows the distance of the echo from the radar site. When you use this scope, the antenna must be stationary and pointing towards the echo. A range strobe (shown in fig. 36) permits you to expand any 5-mile sector along the azimuth bearing so that it occupies the full width of the display. The main bang (shown in fig. 36), permits you to see what part of the sweep you are strobing.

8-4. **Range and Height Indicator (RHI).** The range and height indicator (shown in fig. 37) presents a vertical cross section of the echoes along any azimuth from the earth's surface to the height limit of the scope. Of course, you must stop the antenna rotation at the azimuth where you want to view the vertical cross section. Operate the antenna so that it oscillates in a vertical plane when you use the range and height indicator. As shown in figure 37, you can manually raise the antenna by turning the handcrack clockwise (CW), and lower it by turning the handcrank counterclockwise (CCW). Range markers are also displayed on the face of the scope in figure 37. The RHI scope has two scales. This scope may be set to scan echoes up to 40,000 feet, or it may be switched to double the scale (thus detect echoes up to 80,000 feet within 120 nautical miles). Using the RHI in conjunction with the PPI echo storage feature, you get an accurate three-dimensional interpretation of the precipitation pattern.

8-5. **Plan Position Indicator (PPI).** Figure 38 shows the PPI scope that presents a maplike picture with the position of the antenna at the center. It indicates range and azimuth (direction) throughout 360°. Range markers appear as concentric circles about the center of the scope. The FPS–77 PPI scope has many advantages over previous weather radar PPI scopes. It can be viewed in a well-lighted room, and it is larger for greater

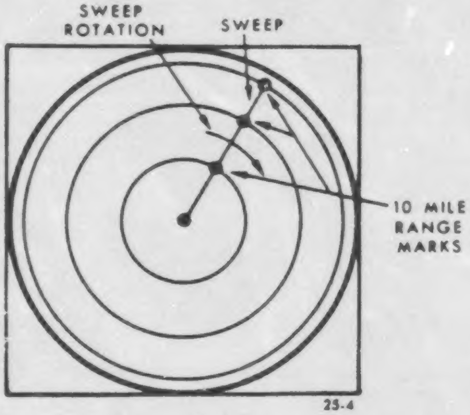
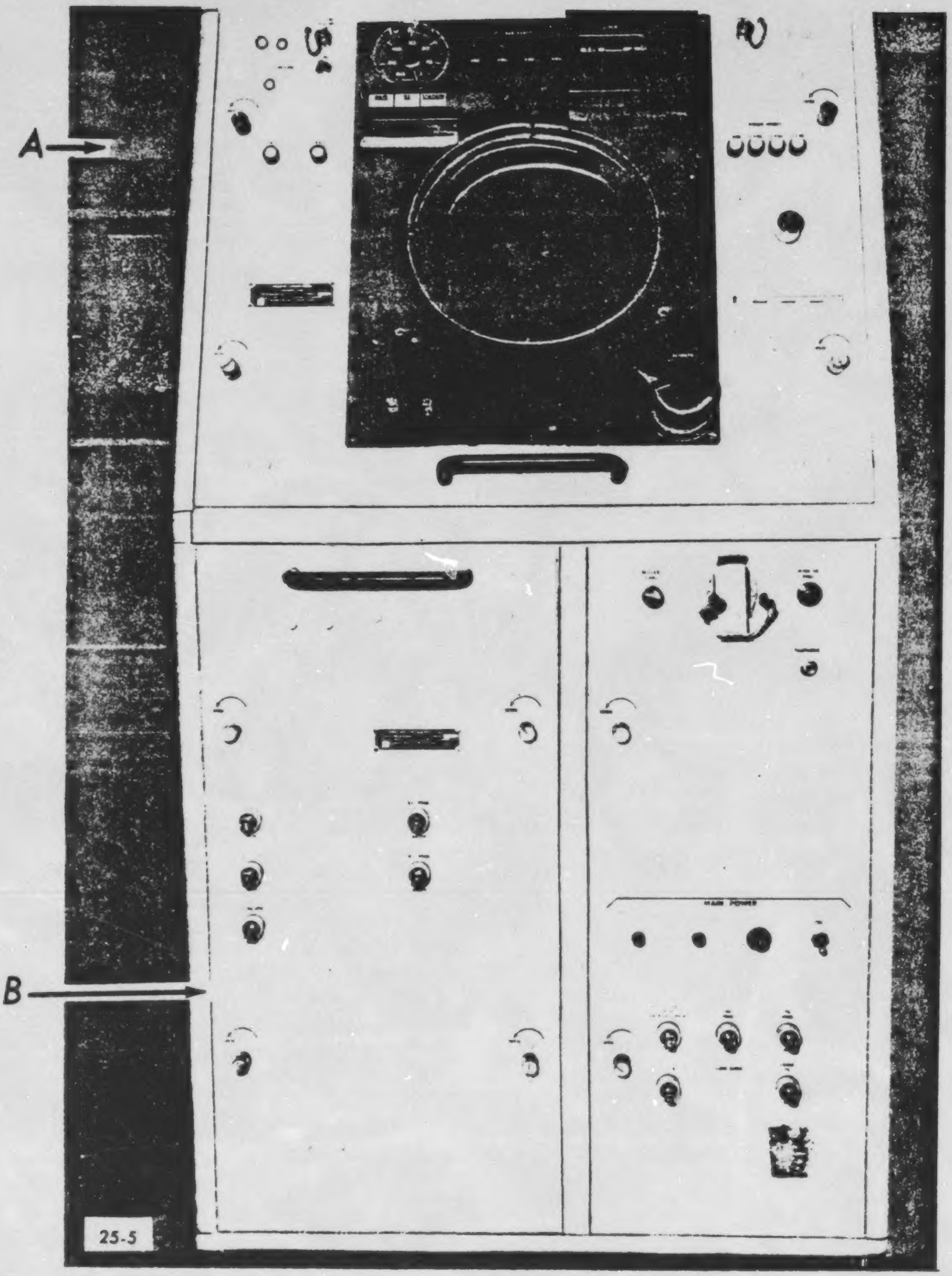
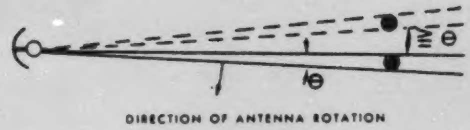


Figure 38. Main PPI scope presentation.

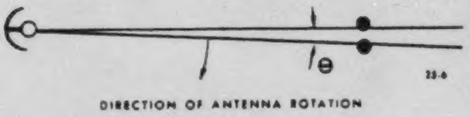


A. PPI SCOPE. B. POWER SUPPLY.

Figure 39. AN/FPS-77 remote scope.



A DISTANCE BETWEEN ECHOES GREATER THAN BEAM WIDTH



B DISTANCE BETWEEN ECHOES LESS THAN BEAM WIDTH

Figure 40. Bearing resolution.

detail, therefore more accurate in locating targets with respect to surrounding geographical landmarks.

8-6. The sweep ranges on the PPI scope are 30, 60, 120, and 200 nautical miles. In addition, the main PPI has a storage feature that allows the operator to retain a horizontal picture of the echoes on the main PPI scope while he makes vertical scans at several points through the echoes.

8-7. *Remote indicator*. The remote indicator shown in figure 39 is housed in a single metal cabinet. It can be located as far as 5500 feet away from the main console. The remote indicator repeats the display of the console PPI. Signals to the console PPI are also applied to the remote PPI. The two scopes are nearly identical; the remote PPI, however, lacks the control switching. Controls at the remote PPI are limited to CRT (cathode-ray tube) controls, such as focus and intensity. The remote PPI operates only when the console PPI operates.

8-8. **Radar Terms.** There are numerous technical terms associated with radar. However, we are primarily interested in terms used to describe the display of weather phenomena on scopes. Some of these terms are:

- Attenuation.
- Resolution.
- Refraction.
- Anomalous propagation.

8-9. *Attenuation*. Radar attenuation is a reduction of radar energy caused by reflection, absorption, or scattering. Although the gases of the atmosphere cause some attenuation, the quantity is negligible. Most attenuation is caused by water vapor, cloud droplets, and liquid precipitation. Of these, liquid precipitation or dense concentrations of large water droplets in cumulonimbus clouds cause more attenuation than water vapor. As the transmitted radar energy intercepts a precipitation area, part of the energy is reflected back to the antenna and is displayed as an echo. Some of the energy is absorbed by the precipitation, and still more is scattered or dispersed so that it is not reflected back to the antenna. This results in less available transmitted energy to detect targets beyond the precipitation area. The heavier the pre-

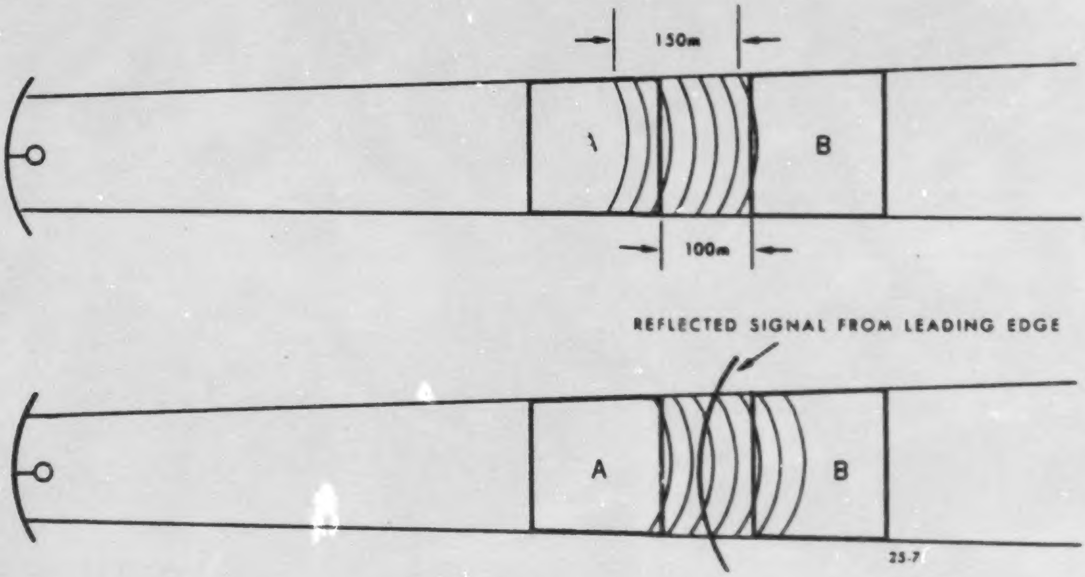


Figure 41. Range resolution.

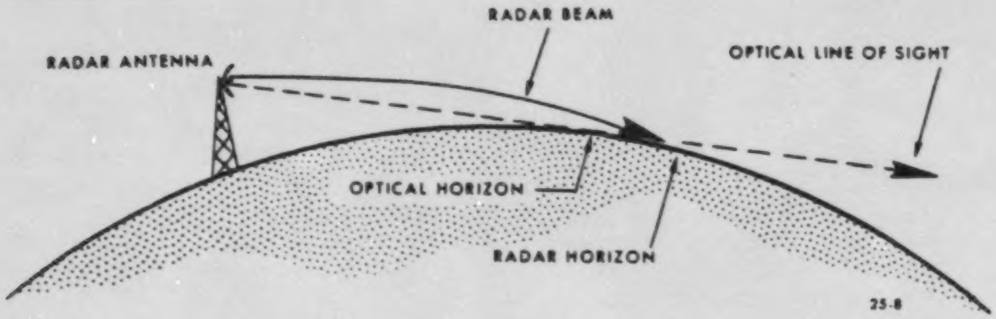


Figure 42. Extension of the radar horizon due to refraction.

cipitation, the greater the return signal (also the brighter the echo); consequently, the attenuation is more pronounced beyond that echo. This explains the existence of the V-shaped notch on the far side of a heavy precipitation echo.

8-10. *Resolution.* Resolution is the ability of the radar set to differentiate between two targets. When two targets come within a certain distance of one another, they appear as one echo on the scope. There are *three types of target resolution—bearing, elevation,* and *range* resolution.

8-11. Bearing resolution is the ability of a radar set to separate two closely spaced targets at the same range and elevation. Bearing resolution is a function of radar beamwidth. Figure 40 illustrates the effect of beamwidth in target separation. In detail A, the distance between the targets is greater than the beamwidth, allowing for a "break" in signal return as the beam passes between the targets. Detail B illustrates the effect of the beam as it passes from one target to the other when they are less than a beamwidth apart. There is no interruption in signal return. Signals begin returning from the second echo before signals stop returning from the first echo. The scope shows these two targets as a single echo. This explains why a solid line of echoes sometimes appears to break-up into individual cells as the line approaches the radar site and appears to merge into a solid line again as it moves away from the radar. For example, suppose the echoes in detail B of figure 40 represent targets at a 100-mile range. Should these targets move within 15 or 20 miles of the radar, they would likely appear as two targets even though the distance between them remains unchanged.

8-12. Range resolution is the ability of a radar set to differentiate between two targets at the same bearing but at different ranges. It is a function of the pulse length rather than beamwidth. The shorter the pulse length, the better the resolution. The FPS–77 has a pulse length of 2 microseconds (equivalent to 600 meters). This limits the distance between discernible echoes at the same bearing to 300 meters or 984 feet.

8-13. Figure 41 illustrates why range resolution is equal to half the pulse length. As the leading edge of the pulse reaches the more distant target (B) and begins returning signals, a 50-meter portion of the pulse is still returning signals from the nearer target (A). As the trailing edge passes from the first target and ceases to return signals, the reflected signal from the leading edge of the pulse has traveled back 50 meters. As a result, there is a 50-meter separation between the last signal returned from the nearer target and the first signal returned from the more distant target. If the difference between the two targets were only 75 meters (or half the pulse length), the signals reflecting from the more distant target (from the leading edge of the pulse) would return to the first target just as the reflection of the trailing edge of the pulse was leaving this target. This results in both reflections traveling back to the radar together with no separation between them to appear as one target on the scope. Therefore, for a given pulse length, the minimum distance between two targets for individual target display, within range, must be greater than one-half the pulse length.

8-14. Elevation resolution is the ability of a radar set to differentiate between two closely spaced targets that are positioned at the same range and bearing, but at different elevations. Again, it is a function of the beamwidth. Since the beam of the FPS–77 is conical in shape, the vertical and horizontal beamwidths are identical at any given range. Consider, for example, that instead of a horizontal sweep, detail A of figure 40 represents a vertical sweep from 0 to 4°. Therefore, the difference in elevation between the two targets is sufficient to display the echoes at two different elevations as the antenna is raised from 0 to 5°. Elevation of the beam through the targets as shown in detail B of figure 40, however, would display only one echo, since the vertical distance between targets is less than the beamwidth. Another factor affecting resolution or even detection, is the refraction of the radar beam as it passes through the atmosphere.

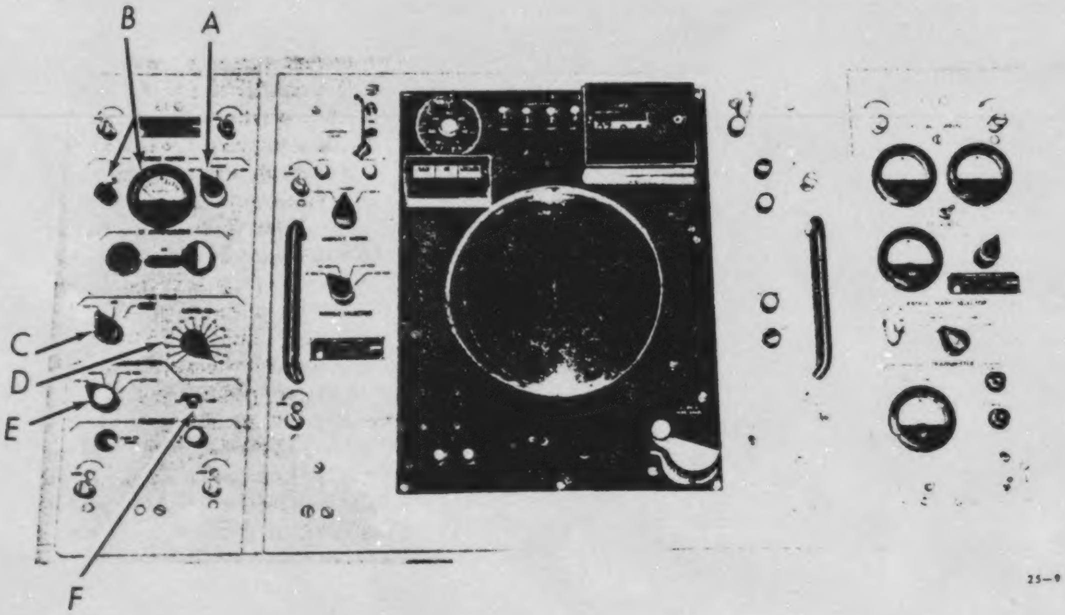
8-15. *Refraction.* Density differences cause the bending of the radar waves through the atmosphere. Under normal atmospheric conditions, when there is a relatively gradual decrease in temperature and water vapor with height, the radius of curvature of the radar beam for nearly horizontal propagation is about one-third greater than that of the earth. Thus, as shown in figure 42, the radar horizon is about 15 percent greater than the optical horizon.

8-16. *Anomalous propagation.* Under abnormal atmospheric conditions, the beam can be refracted or distorted so that it causes echoes to appear on radar scopes where no clouds exist. The most significant effect, however, of anomalous propagation (AP) is that it often displays targets at a range other than the actual range of the target. A point to remember is that during precipitation, the conditions that are favorable for AP are normally absent. *Beware when inversions are present!*

8-17. **Operating Controls.** There are numerous controls on the console—too many for this discussion to cover. It is important for you to remember that some of these controls are sensitive, and that damage to the set or impaired operation may result if you misadjusted them. A thorough training program will help insure proper use of the equipment. This section discusses some of the controls that you will use most frequently; it will help you to understand some of the capabilities of the FPS–77.

8-18. *IF attenuator.* The attenuator control (located just below the NOISE METER, fig. 43,B) allows you to vary receiver attenuation from 0 to 109 db in 1-db steps. The main purpose of the IF attenuator is to permit comparison of target echo intensities by the "gain reduction methods." Using the attenuator gain reduction allows you to pick out the stronger cells. It also permits an observation of highly reflective weather phenomena (such as "bright band" in stratiform rain) that would otherwise be masked by the surrounding area of reflectivity.

8-19. *Range normalization.* The RANGE NORMALIZATION switch (fig. 43,E) causes targets of equal density or size within the normalized range to be displayed at their respective intensities. Without range normalization, the nearby target (in most cases) appears to be the strongest because of its location, whereas a target farther away might actually be the stronger in intensity. Normalization is provided over a range of 1 to 30, 1 to 60, or 1 to 120 nautical miles, depending on



A. NOISE METER OFF/STANDBY/OPERATE SWITCH.
B. NOISE METER AND METER ADJUST CONTROL.
C. ISO ECHO OFF/ON/ALARM DISABLE SWITCH.
D. ISO ECHO LEVEL-DB CONTROL.
E. RANGE NORMALIZATION SWITCH.
F. IF POSTAMPLIFIER LIN/LOG SWITCH.

Figure 43. Main PPI scope and reference signal generator.

the position you select with the RANGE NORMALIZATION switch.

8-20. *ISO ECHO contour and alarm.* The ISO ECHO contour facility permits targets of very high density (such as storm centers) that are surrounded by areas of moderately high density to be clearly displayed. Because of the high signal strength of the target returns, the IF postamplifier always operates in the logarithmic mode during weather conditions in which ISO ECHO is useful (fig. 43,F). When ISO ECHO is used, video signals with amplitudes that exceed a predetermined threshold level are displayed as if their amplitude were zero. Thus, a storm center appears on the PPI scope as a highlight surrounded by a dark patch whose density decreases gradually towards the fringes of the storm.

8-21. There is also an alarm feature for the ISO ECHO circuits (fig. 43,C). This feature is helpful and time saving. For instance, suppose you are working in a weather station and you observe clouds developing. You want to be aware of any heavy development, should it occur. Set the alarm; this will enable you to take care of your regular duties without the frequent "cloud growth" checks that are necessary when there is no alarm. When the signal reaches the intensity level you have selected, the alarm buzzer sounds to alert you to the increased development of the clouds. In this way it prevents cloud development from going unnoticed while you are busy with other things.

8-22. *Echo memory.* Echo memory is a new feature on weather radars. The PPI scope has a dark-trace, stored-pattern tube that retains the target pattern until it is deliberately erased. This also permits a target pattern to be observed and photographed without the confusion caused by a moving trace. To preserve the life of the tube, it is important that you make no attempt to *increase the contrast* beyond that necessary to make the targets and range marks visible. Advancing the INTENSITY controls beyond this point makes the pattern difficult to erase and may burn the screen of the CRT. Do not use either the writing or the erasing facilities more often than is operationally necessary. Now that you know the capabilities of radar sets, you have taken an important step toward learning observational techniques.

8-23. **Radar Observing Techniques.** Radar echoes of cloud and precipitation areas are classified according to their general appearance. This classification is standardized to make it easier to report echo data and decipher radar weather messages. Whenever you use the weather radar set, you ultimately make these first classifications automatically with each echo you observe. Observation techniques vary from one operator to another, as well as with the radar type that is used. Although observation methods vary slightly when operating different radars, the differences result in only two areas—the name of the controls and the capability of the sets. This discussion is related to the FPS-77, since it is planned to be the mainstay AWS radar set in the 1970s.

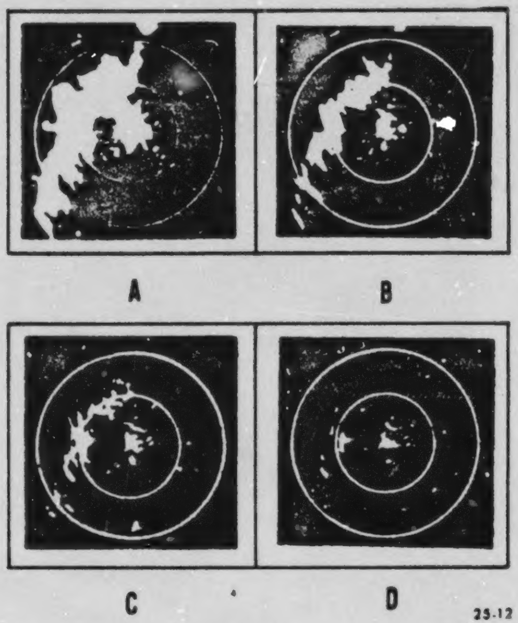


Figure 44. Effect of gain reduction on scope display.

8-24. *Echo character and coverage.* When an echo first appears on the scope, the first thing you must consider is how to classify the echo. To classify for reporting purposes, you must think of *configuration,* coverage, continuity of pattern, and meteorological processes. Foldout 5 is a synopsis for classification of radar echos. Among other things the synopsis describes their definitions and contractions for reporting on the radar observation form. The best way to search for echoes on the FPS-77 is to set the ISO ECHO threshold at a low level (10 db). With the threshold at a low level, only the weakest signals are pictured; you can fill in the ISO ECHO areas on subsequent scans by raising the threshold to isolate the strongest returns. During your search, you should reduce the gain when scanning an area of echoes to see if there is an embedded line of cells within the area pattern. Figure 44 illustrates the effect of gain reduction on a scope display with gain highest in A and reduced successively in B, C, and D. Notice how the stronger cells persist as the gain is reduced; in figure 44,D, only the strongest echoes can be seen. This practice locates areas of heavier activity. You should report both the area and embedded lines separately in the radar observation. The forecaster passes this information on to pilots in his weather briefings. The forecaster is also interested in line activity with respect to the intensity of precipitation and strong surface winds that could affect a station in the squall line's path.

8-25. *Echo type.* Convective precipitation, such as showers and hail, is distinguished from stratiform precipitation by the appearance of the echo. Convective activity indicates the possibility of thunderstorms. Convective echoes appear with sharp outlines and uneven textures because of the large water droplets and variations in precipitation intensities. Also, as you use higher IF ATTENUATION values, the echoes do not disappear uniformly. Stratiform echoes, on the contrary, show uniform sheetlike echoes with fuzzy borders, and the echoes disappear uniformly as you *increase* the IF ATTENUATION.

8-26. *Echo intensity.* In addition to determining the echo type, it is necessary to determine the *intensity* of the echo. Determining echo intensity by subjective brightness is not necessary. The FPS-77 provides quantitative measurements of signal intensity by using the ISO ECHO feature.

8-27. The operation of the ISO ECHO feature is based on known factors of reflectivity that are used to arrive at a level of signal strength. This level is expressed in decibels (db). (The db level indicator is located on the FPS-77 radar below the IF ATTENUATOR label.) From the db level you can determine the intensity of an echo.

8-28. You must know the transmitted power and receiver noise level. They should be 250 kw and 9.5 db respectively; otherwise, you must apply a correction. Operate the receiver in the LOG mode, and be sure that the ISO ECHO circuit and receiver gain are calibrated. Read the ISO ECHO LEVEL-DB switch setting (this is a db above the receiver noise). Add or subtract the correction factor if the radar set does not have a noise level of 9.5 db or transmitter power of 250 kw. For example, if the set is operating at 10.5 db, receiver noise level, you must add 1 db to the db reading on the IF ATTENUATOR since the receiver has a noise level higher than 9.5 db. This is based upon instructions in Chapter 3, Section 2, of TO 31M6-2FPS-77-2.

8-29. Table 10 contains the information for determining echo intensities for both normalization modes (60 NM and 120 NM). After applying corrections, if any, enter the table with the corrected db value and read the corresponding intensity value. Table 10 is based on the nomogram in Chapter 3, Section 2 of TO 31M6-2FPS-77-2. This procedure can be used for all echoes.

8-30. Echoes in the *strong* category very likely have the potential for producing hail. *Very strong* echoes may be associated with large hail, damaging winds, or even tornadoes. Remember, there are two limitations when measuring intensity. You cannot accurately determine echo intensity at ranges over 120 nautical miles. Also, it is unreliable to try to measure echo intensity through an area of strong precipitation. A V-shaped notch behind an echo is usually caused by attenuation of the signal by heavy precipitation. Closely watch the echoes that display strong intensities because they indicate severe weather. You can determine the *tendency* of the echo intensity by comparing it with previous observations.

TABLE 10

IF ATTENUATION AND ECHO INTENSITY (AN/FPS-77V)

RANGE = 120NM; normalization to 60NM; LOG mode

IF Attenuation (db above noise)	Echo Intensity
13 and below	very weak (--)
14 - 29	weak (-)
30 - 45	moderate
46 - 56	strong (+)
57 and above	very strong (++)

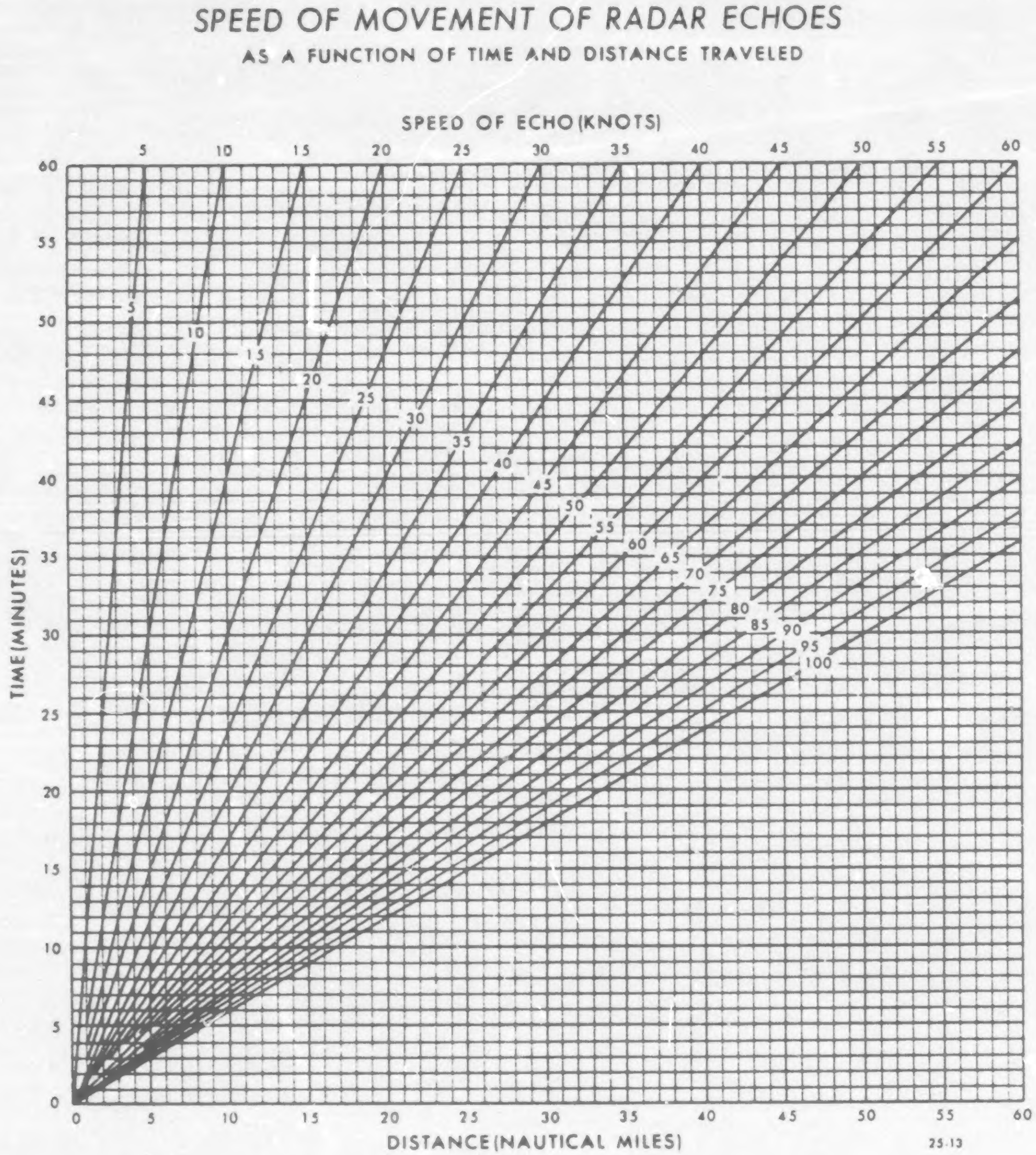
RANGE - 120NM; normalization to 120NM; LOG mode

IF Attenuation (db above noise)	Echo Intensity
8 and below	very weak (--)
9 - 24	weak (-)
25 - 40	moderate
41 - 51	strong (+)
52 and above	very strong (++)

8-31. *Echo location and size.* The initial search reveals the general location of echoes. To find the azimuth (bearing), use the AZIMUTH handcrank and the AZIMUTH scale to pinpoint the direction. Use the RANGE STROBE on the A/R scope to determine the distance to the echo. You can also find the width of the echo from the A/R scope by using the RANGE STROBE to measure from one side of the echo signal to the other side.

8-32. *Echo movement.* Use of the storage feature on the PPI scope requires a new approach in operational techniques. To obtain full advantage of this storage feature, you must operate the set with greater care and intelligence than when you used previous weather radar sets with conventional PPI displays. You can retain PPI patterns for a period of up to 1 hour to determine motion. However, this precludes frequent changing of PPI sweep ranges. After the desired period of time has passed (which is indicated by an elapsed time clock on the PPI, you can write a new PPI pattern on the scope without erasing the previous pattern (that will have faded slightly). The new echo position, when compared to the stored echo position, indicates echo movement and development. In combination with the elapsed time intervals, you can determine the *echo direction* and *speed of movement*. A chart, as illustrated in figure 45, displayed or posted near the PPI scope provides a convenient aid to determine speed of movement.

8-33. *Echo heights*. Use the RHI scope to determine echo heights (fig. 46). On the FPS-77, you can read the true altitude of the echo top (above the height of the antenna) directly from the scale. Then, of course, you must convert the right of the echo top to MSL by adding the MSL height of the antenna. You also have to make a half-beamwidth correction. Figure 47 is an extract of the half-beamwidth correction graph. As mentioned earlier, it is not necessary to make an earth curvature correction since the RHI scope has this feature built into the sweep.



SPEED OF MOVEMENT OF RADAR ECHOES
AS A FUNCTION OF TIME AND DISTANCE TRAVELED

Figure 45. Nomogram for determining speed of radar echoes.

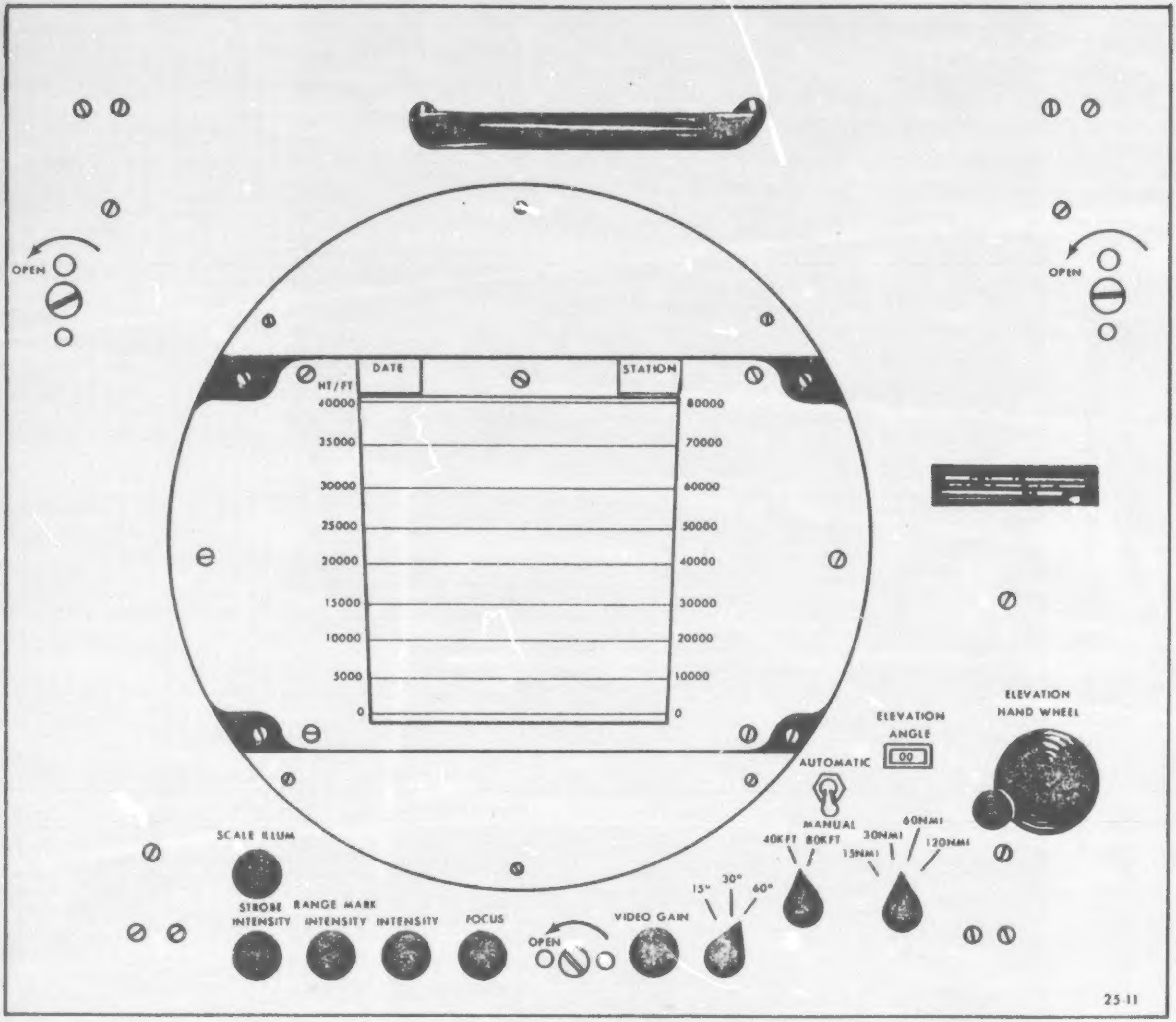

OPEN
OPEN
DATE
STATION
HT/FT
40000
35000
30000
25000
20000
15000
10000
5000
0
80000
70000
60000
50000
40000
30000
20000
10000
0
ELEVATION ANGLE
00
ELEVATION HAND WHEEL
AUTOMATIC
MANUAL
40KFT
80KFT
15NMI
30NMI
60NMI
120NMI
SCALE ILLUM
STROBE INTENSITY
RANGE MARK INTENSITY
INTENSITY
FOCUS
OPEN
VIDEO GAIN
15°
30°
60°
25-11

Figure 46. RHI scope.

8-34. ***Bright band.*** The bright band is a striking feature observable in stratiform rain on the RHI scope. This bright band is caused by a horizontal layer of stronger reflectivity (about 1000 feet in depth). Bright bands appear narrow and intense within a fairly stable layer of air. As the stability of the airmass decreases, the bright band tends to become broader and less distinct.

8-35. A bright band occurs in the region of melting snow *about 1000 feet below the melting level* (0° C.) and is always present in widespread stratiform rain. The height of the bright band varies according to season and latitude. Such a band is not present in the active parts of thunderstorms because in the strong updrafts there is no clear-cut altitude above which the precipitation is predominantly ice and below which it is water. However, a bright band may be present in mature or decaying thunderstorms in areas of relatively gentle precipitation where strong updrafts no longer occur. To more clearly identify the bright band and its characteristics, make occasional RHI scans at short range with reduced gain during observations in rain. The height of the top of the bright band may be reported in column 10 of the radar recording form in hundreds of feet MSL (e.g., MLTLVL 75).

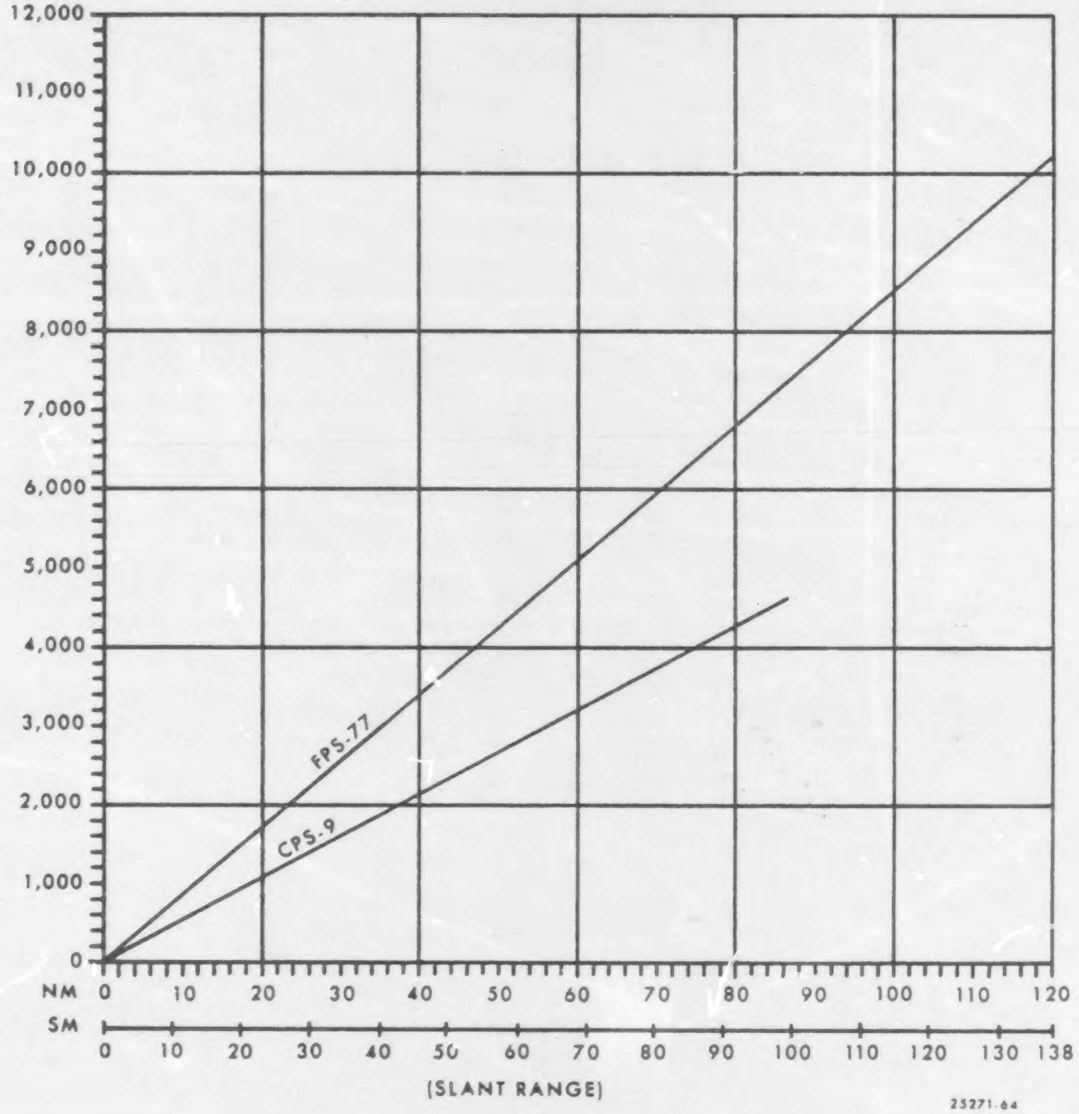


Figure 47. Half-beamwidth correction graph.

8-36. The bright band effect is caused by several processes associated with melting snow particles as they fall into warmer air. The radar return from small water drops is about five times greater than that from ice particles of the *same mass* and *shape*. As the falling snowflakes become coated with water, their reflectivity increases. As the particles melt, they accelerate from the slow fall velocity of snow (1/2 meter per second) to that of rain (4 to 8 meters per second). The increase in fall velocity decreases the number of droplets per unit volume below the melting level and causes a corresponding decrease in radar reflectivity per unit volume. Thus, the melting process creates a horizontal layer of strong radar reflectivity that is much stronger than the snow above and a little stronger than the rain below. Just as bright band phenomena should be brought to the forecaster's immediate attention, so should all storm echoes.

8-37. **Storm Echoes.** No two people are *exactly* alike; neither are two storms exactly alike. Thus, this discussion of storm patterns describes only some general features peculiar to three types of storms—squall line, tornado, and hurricane.

8-38. *Squall line.* A squall line pattern appears very similar to a cold front pattern on the radar scope. The squall line most generally precedes the cold front position. The cells within the bands are constantly undergoing a process of formation and dissipation. They appear to form or intensify on their forward edges and to dissipate on their trailing edges. Squall line activity is a chief suspect for tornado development.

8-39. *Tornado.* A hook-shaped echo may indicate a possible severe weather condition. Tornadoes usually produce a strong figure 6-shaped appendage on the mother cloud echo. They may appear very similar to other strong echoes during thunderstorm activity. Sometimes they appear at higher elevations, making it necessary for you to raise the antenna in order to detect the hooks. You should remember that not every echo of this shape is always a tornado. However, when an echo has a clearly defined figure "6" spiral, with dimensions of 5 to 10 miles across, and meets the criteria for severity, it is very likely a surface tornado or one that is aloft.

8-40. *Hurricane.* One of the most valuable services performed by coastal radar installations is the tracking of hurricanes that move within range. The first evidence of an approaching hurricane on the radar is generally the appearance of the outer band that is often in the nature of a squall line some 200 miles from the center. This is a line of heavy precipitation, frequently accompanied by thunderstorms and tornadoes. In a large, mature hurricane, there may be a number of prehurricane squall lines as much as 400–500 miles from the eye. Usually, between these lines there is a gap of 50 miles or so without precipitation. The first spiral band usually follows the squall line by about 50 miles. The hurricane spiral bands are about 20 miles apart in the outer portions of the storm, but near the center of the storm they tend to blend together. The echoes arranged in these spiral bands and those forming the wall cloud are associated with the violent wind squalls of a hurricane. The greatest echo heights, however, are found in some of the more intense cells of the prehurricane squall line and in the wall cloud surrounding the echo-free eye at the storm center.

8-41. Although it is quite variable, the diameter of the eye normally ranges from 10 to 30 miles. Because the rain may not be symmetrical around the eye, it may not be possible to locate the center with accuracy from the echo configuration. To help in locating the center in cases where the eye is indistinct, you can use a spiral overlay. Adjust the overlay manually so as to fit a portion of a well-defined spiral band. After a satisfactory fit has been obtained, indicate the position on the overlay. Although this method may give a location that is sometimes in error by more than 30 miles, it is still a useful guide. In any case, the eye is the most reliable feature of the hurricane that can be tracked to provide the direction and speed of the storm.

8-42. As the storm moves northward away from the Tropics, the moisture in high-level clouds is more apt to be converted into ice particles. If this happens, some of the ice particles will get fairly large and may be detectable at long ranges. These ice particles may give the illusion that the storm has become much more intense or has suddenly grown in height because the large-size ice particles are more readily detectable by radar than the small, liquid cloud particles. Figure 48 shows a schematic illustration of a hurricane pattern.

8-43. *Operating precautions.* Experienced weather equipment technicians perform maintenance on the FPS–77. However, there are several operating precautions that you can observe to prevent serious damage to the set. Avoid excessive magnetron current. Apply current to the magnetron slowly, and lower the current when magnetron arcing occurs. Though the antenna can automatically scan in elevation and azimuth at the same time, it serves no operational purpose, and causes unnecessary strain on the antenna drive mechanism. To prolong the face of the PPI tube, operate the INTENSITY at a level where the display just becomes visible. Do not attempt to obtain dark patterns on the PPI tube because this makes it difficult to erase these patterns. Use the ISO ECHO controls during the writing mode to dampen the strongest echoes and reduce the

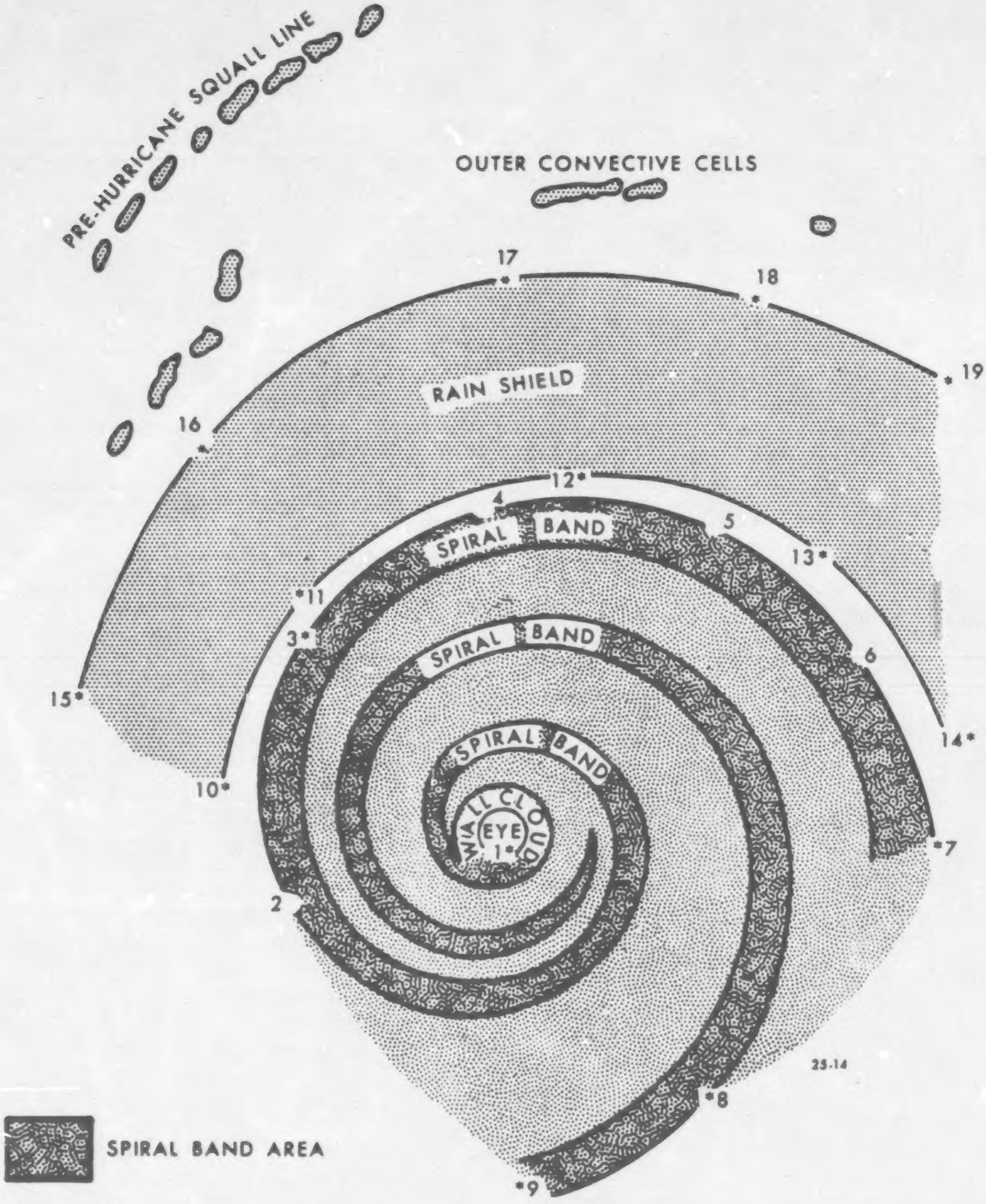

PRE-HURRICANE SQUALL LINE
OUTER CONVECTIVE CELLS
17
18
19
RAIN SHIELD
16
12
4
SPIRAL BAND
5
13
11
3
SPIRAL BAND
6
15
14
SPIRAL BAND
10
WALL CLOUD
EYE
1
7
2
25-14
8
9
SPIRAL BAND AREA

Figure 48. Schematic illustration of bands and eye of a hurricane.

chance that these strong echoes will be written too dark for erasure. Above all, follow the operating instructions posted at the set.

9. Observing Facilities, Logs, and Equipment

9-1. Air Weather Service provides meteorological service to the Air Force and Army. Accurate weather observations are an important part of this service. To observe evaluate, record, encode, and disseminate observations of meteorological elements near the earth's surface. a proper observing site is needed. The site selected for this purpose is commonly called the *representative observing site (ROS)*.

9-2. **Observing Site.** The observing site should be at a location best suited to observe and evaluate the meteorological elements that concern the observing station. When selecting a suitable location, consider local climatology, observing structure, length of instrument cable runs, and communications requirements.

9-3. The structure should be a suitable building in which to perform assigned tasks and one which provides adequate safety, working space, and basic human comforts. When selecting a suitable structure for surface observing, give special considerations to location and field of view.

9-4. *Fixed surface observing.* The preferred location of the surface observing site on an airfield is at the midpoint of the primary instrumented runway with the minimum permissible lateral clearance from the centerline of the runway. However, any location on the airfield complex that affords an unobstructed view of both ends of the primary instrumented runway is acceptable.

9-5. The preferred view from within the observing site is 360°. This view should be unobstructed for a distance of 3 miles or more. An acceptable view is 360° of the airfield complex from an outside viewing area, provided there is a 270° view from within the structure. This 270° view must encompass the complete runway and approach zone complex, and it should be unobstructed for a distance of 1½ miles or more.

9-6. *Structures.* The primary surface observing structure should be designed to provide the necessary space, safety, field of view, and comfort for the observer. In addition it must be suitably located to provide the most advantageous view of weather conditions over the area of major concern.

9-7. The preferred design for a surface observing structure is a separate building near the midpoint of the primary instrumented runway (see paragraph 9-5) with an observer's cab elevated to provide unobstructed vision. The building should have an area of 600–1000 square feet and include an observer's cab (200 sq ft), human comfort facilities (200 sq ft), and an equipment/maintenance area (200–400 sq ft). The structure should be air conditioned and have hot and cold running water and toilet facilities. Foldout 6 is an example of how the structure can be built and equipment laid out to meet these requirements.

9-8. Units not having an observing structure that meets these requirements may use a portion of an existing structure if representative weather observations can be taken from it. An observing site is seldom located in an operational control tower cab. This may occur when there is no other suitable structure available; then only when approval comes from the host installation commander.

9-9. Observing structures should be equipped with instrument readouts positioned so that the required observations can be made and disseminated with maximum efficiency. Give special attention to lighting requirements. Also to the observer's inability to adjust his eyes to both darkened conditions outside the structure at night as well as to internal light reflection on window areas. Dimming controls that can be readily operated by the observer should be used when possible within the observing structure.

9-10. *Upper-air observing.* The primary upper-air observing site is considered to be the location of the pressure measuring instrument used to calibrate the flight instrument. A site should be selected that minimizes the probability of losing data due to fixed obstructions, such as buildings, trees, and towers. Also, obstructions around rawinsonde observing sites seriously affect the ability of the antenna to track on-target when the angular altitude of the obstruction is approached by that of the target.

9-11. Angular altitudes of obstructions around PIBAL sites, with the exception of small pipes or masts, should not exceed six° above the horizontal plane. Select an alternate site for PIBAL functions to be used when local wind conditions do not permit a balloon to be released from the normal observation site.

9-12. When establishing an upper-air observing site, another consideration is the location of an adeuqate balloon launch area. It should be near the observing site, relatively free of obstructions, such as buildings, trees, towers, or cables, and located to minimize interference of the balloon with the takeoff and landing of aircraft.

9-13. *Tactical observing.* Equipment location should depend upon the specific geography of the location at which the equipment is situated. Certain tactical equipment sets are issued with associated shelters. When the shelter is not a component part of the tactical set, it may be obtained by ordering from the table of allowance (TA); TA

006 for tent-type shelters or TA 010 for vehicle-type shelters, with the exception of the following conditions:

a. Portable functions are not normally authorized a shelter.

b. Mobile observing functions are provided shelter as a component part of the basic equipment set when using the AN/MMQ–2, Manual Meteorological Station. The S–13/TM, Inflation Shelter, is provided in the AN/TMQ–18, Meteorological Set.

9-14. *Observing support functions.* Observing support functions generally are located with and use the same structure as the function or unit they support such as:

a. The *forecaster support* function is situated adjacent to the forecaster work area within the weather station or forecast facility.

b. The *weather editing* function uses the weather communications center structure. The *communications editing* work area should be positioned within the communications center to make it easy to manage and monitor the weather communications circuits.

c. Solar observing functions making magnetometer, riometer, and ionospheric observations normally are situated in existing structures. Solar optical and radio telescope observations are made from established observatories operated by the Air Force and other agencies.

9-15. **Operating Logs and Records.** To maintain the reliability of your pressure observations, routine comparisons must be made between your aneroid barometer and its accurate cousin, the mercurial barometer. This comparison is recorded on AWS Form 85, and is maintained as an integral part of the station records.

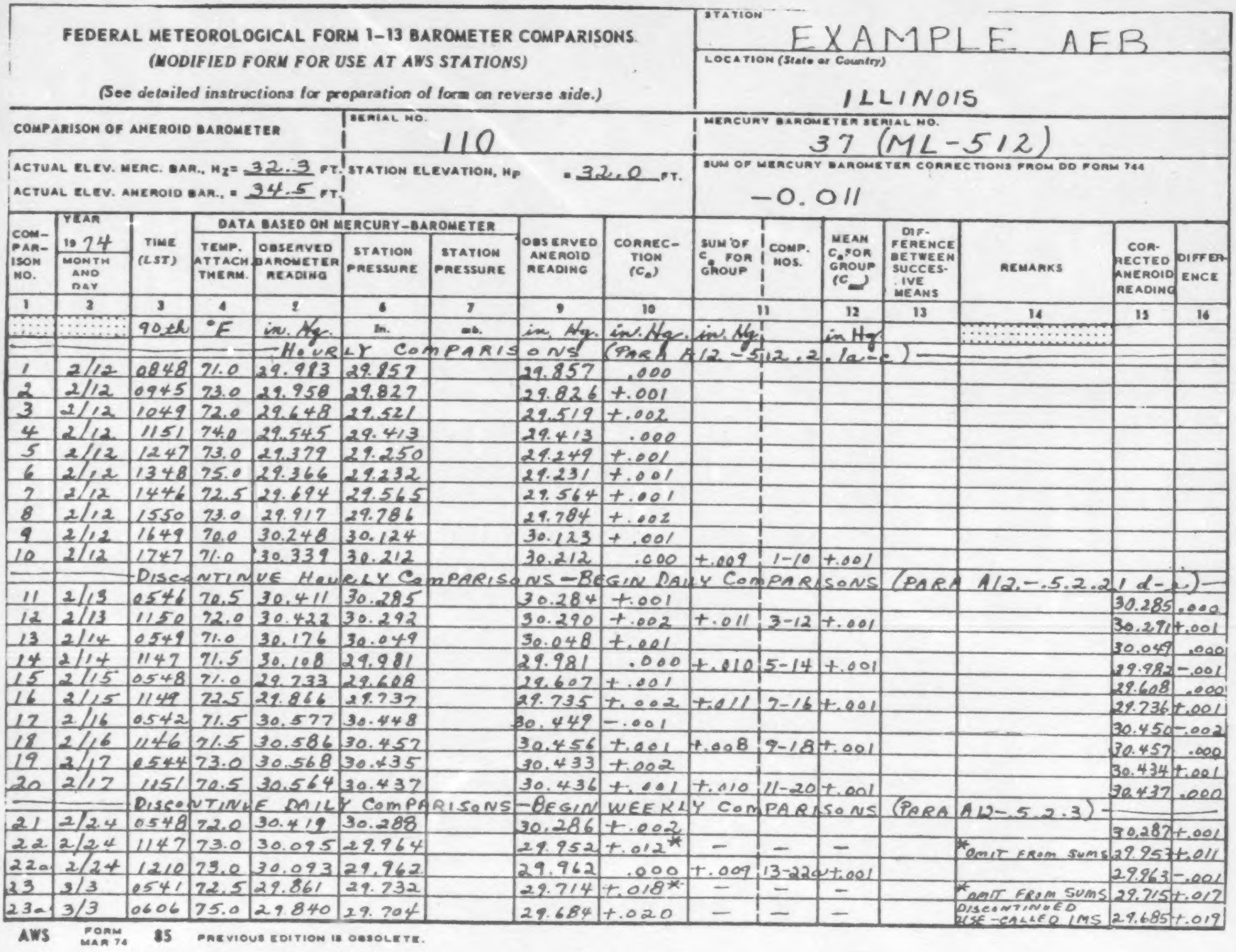
9-16. *Barometer comparisons (AWS Form 85).* Whether you are making a routine comparison or comparing a newly installed aneroid barometer, enter comparison readings on AWS Form 85. For a routine comparison, the frequency of readings is weekly. For standardizing a new aneroid barometer, daily readings are necessary. Entries for comparison readings for a new aneroid are illustrated by the sample AWS Form 85 in figure 49. Assign each reading a comparison number and enter in column 1. The two daily readings are dated and annotated for time. You can see that the readings occur at 6-hour intervals and at the same times each day. Make all pressure readings and subsequent entries on the Form 85 to .001 inches or 0.1 mb as appropriate.

9-17. Next, enter observed data from both instruments. This includes the temperature of the attached thermometer (column 4), observed mercurial reading (column 5), and observed aneroid reading (column 9). Make the pressure readings as close in time to each other as possible to eliminate effects of atmospheric pressure changes. Observe the headings in columns 4 and 5, indicating the units of each entry. After entering the observed data, apply the temperature correction and sum of corrections to the mercurial reading, and then enter the result in the *station pressure* column relating to the unit (inches or millibars) observed. Figure 49 shows sample entries.

9-18. These two corrections are derived from separate sources. From Table 5.2.1 in the *WBAN Manual of Barometry* (FMH 8), a temperature correction of −.115 results from coordinate 71.0° F. and 30.0 inches (the closest value to 29.983 is observed). Added to the temperature correction is the sum of corrections provided by the barometer manufacturer. Added together, these two corrections make a *total* correction of −.126. Observed pressure, 29.983, minus .126 explains the 29.857 station pressure. Compare the station mercurial pressure to the observed aneroid, then enter the difference in column 10. Simply subtract column 9 from column 6 and include the algebraic sign (.827 − .826 = +.001).

9-19. Make this comparison for five consecutive days and compute the mean correction for the 10 readings. Referring to the sample Form 85 in figure 49, the previous 10 corrections are totaled and entered in column 11 on the 2/13, 1140 LST line. Indicate also the first and last numbers of the comparisons making up the total correction. Next, find the mean correction from these two items and enter the result in column 12. Make the final entries in column 14, which you see has been divided into 14A and 14B. Column 14A shows the result of applying the mean correction (column 12) to the aneroid reading (column 9). After you do this, if column 14A and column 6 still differ, enter in column 14B the amount it would take to bring column 14A equal to column 6.

9-20. Make comparisons daily until you have 20 consecutive comparisons in which no entry in column 14B has exceeded ±.010 inch or ±0.3 mb. None of the comparisons during the first 5 days should be considered for this purpose. From these 20 comparisons, the mean correction (column 12) may now be posted to the aneroid. Once you post the correction, the aneroid is available for observation purposes, but you cannot yet consider the instrument reliable. Continue the daily comparisons and compute a mean correction every 5 days. Notice in figure 49 on the 120th comparison, the mean correction has been computed from comparisons 11 through 120 and again computed 5 days. Notice in figure 49 on the 120th comparison, the mean correction has been computed from



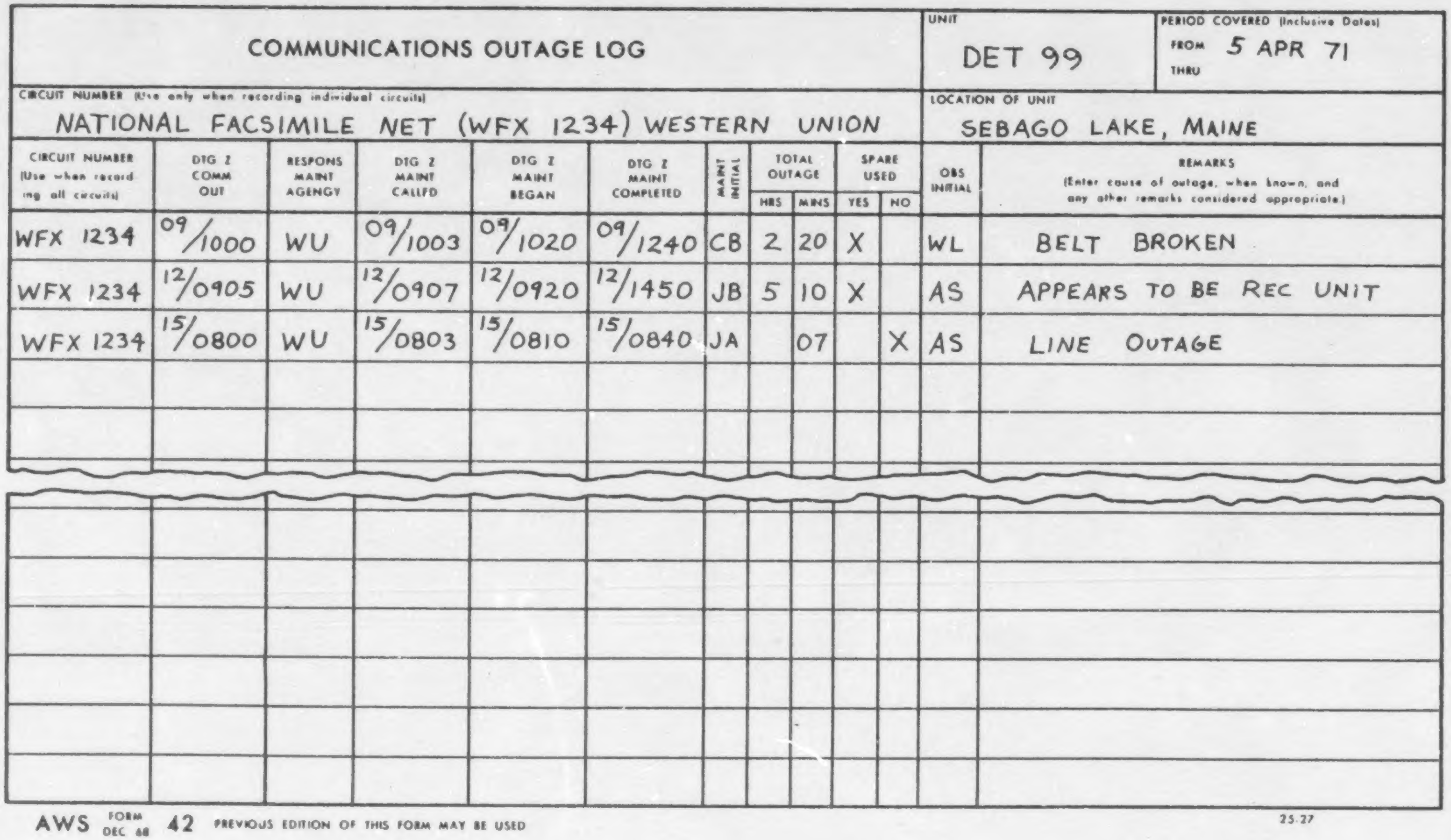
FEDERAL METEOROLOGICAL FORM 1-13 BAROMETER COMPARISONS
(MODIFIED FORM FOR USE AT AWS STATIONS)
(See detailed instructions for preparation of form on reverse side.)

STATION: EXAMPLE AFB
LOCATION (State or Country): ILLINOIS
COMPARISON OF ANEROID BAROMETER
SERIAL NO. 110
MERCURY BAROMETER SERIAL NO. 37 (ML-512)
ACTUAL ELEV. MERC. BAR., H_Z = 32.3 FT.
ACTUAL ELEV. ANEROID BAR., = 34.5 FT.
STATION ELEVATION, H_P = 32.0 FT.
SUM OF MERCURY BAROMETER CORRECTIONS FROM DD FORM 744: −0.011

			DATA BASED ON MERCURY-BAROMETER												
COMPARISON NO.	YEAR 19 74 MONTH AND DAY	TIME (LST)	TEMP. ATTACH THERM.	OBSERVED BAROMETER READING	STATION PRESSURE	STATION PRESSURE	OBSERVED ANEROID READING	CORRECTION (C_a)	SUM OF C_a FOR GROUP	COMP. NOS.	MEAN C_a FOR GROUP ($C_{\bar{a}}$)	DIFFERENCE BETWEEN SUCCESSIVE MEANS	REMARKS	CORRECTED ANEROID READING	DIFFERENCE
1	2	3	4	5	6	7	9	10	11		12	13	14	15	16
		90th	°F	in. Hg.	In.	mb.	in. Hg.	in. Hg.	in. Hg.		in Hg				
—		HOURLY COMPARISONS (PARA A12-512.2.1a-c) —													
1	2/12	0848	71.0	29.983	29.857		29.857	.000							
2	2/12	0945	73.0	29.958	29.827		29.826	+.001							
3	2/12	1049	72.0	29.648	29.521		29.519	+.002							
4	2/12	1151	74.0	29.545	29.413		29.413	.000							
5	2/12	1247	73.0	29.379	29.250		29.249	+.001							
6	2/12	1348	75.0	29.366	29.232		29.231	+.001							
7	2/12	1446	72.5	29.694	29.565		29.564	+.001							
8	2/12	1550	73.0	29.917	29.786		29.784	+.002							
9	2/12	1649	70.0	30.248	30.124		30.123	+.001							
10	2/12	1747	71.0	30.339	30.212		30.212	.000	+.009	1-10	+.001				
—		DISCONTINUE HOURLY COMPARISONS—BEGIN DAILY COMPARISONS (PARA A12.-.5.2.21d-[illegible])—													
11	2/13	0546	70.5	30.411	30.285		30.284	+.001						30.285	.000
12	2/13	1150	72.0	30.422	30.292		30.290	+.002	+.011	3-12	+.001			30.291	+.001
13	2/14	0549	71.0	30.176	30.049		30.048	+.001						30.049	.000
14	2/14	1147	71.5	30.108	29.981		29.981	.000	+.010	5-14	+.001			29.982	−.001
15	2/15	0548	71.0	29.733	29.608		29.607	+.001						29.608	.000
16	2/15	1149	72.5	29.866	29.737		29.735	+.002	+.011	7-16	+.001			29.736	+.001
17	2/16	0542	71.5	30.577	30.448		30.449	−.001						30.450	−.002
18	2/16	1146	71.5	30.586	30.457		30.456	+.001	+.008	9-18	+.001			30.457	.000
19	2/17	0544	73.0	30.568	30.435		30.433	+.002						30.434	+.001
20	2/17	1151	70.5	30.564	30.437		30.436	+.001	+.010	11-20	+.001			30.437	.000
—	—	DISCONTINUE DAILY COMPARISONS—BEGIN WEEKLY COMPARISONS (PARA A12-.5.2.3)—												—	—
21	2/24	0548	72.0	30.419	30.288		30.286	+.002						30.287	+.001
22	2/24	1147	73.0	30.095	29.964		29.952	+.012*	—	—	—		*OMIT FROM SUMS	29.953	+.011
22a	2/24	1210	73.0	30.093	29.962		29.962	.000	+.009	13-22a	+.001			29.963	−.001
23	3/3	0541	72.5	29.861	29.732		29.714	+.018*	—	—	—		*OMIT FROM SUMS	29.715	+.017
23a	3/3	0606	75.0	29.840	29.704		29.684	+.020	—	—	—		DISCONTINUED USE—CALLED IMS	29.685	+.019

AWS FORM MAR 74 85 PREVIOUS EDITION IS OBSOLETE.

Figure 49. AWS Form 85.



COMMUNICATIONS OUTAGE LOG

UNIT: DET 99

PERIOD COVERED (Inclusive Dates) FROM 5 APR 71 THRU

CIRCUIT NUMBER (Use only when recording individual circuits): NATIONAL FACSIMILE NET (WFX 1234) WESTERN UNION

LOCATION OF UNIT: SEBAGO LAKE, MAINE

CIRCUIT NUMBER (Use when recording all circuits)	DTG Z COMM OUT	RESPONS MAINT AGENCY	DTG Z MAINT CALLED	DTG Z MAINT BEGAN	DTG Z MAINT COMPLETED	MAINT INITIAL	TOTAL OUTAGE		SPARE USED		OBS INITIAL	REMARKS (Enter cause of outage, when known, and any other remarks considered appropriate.)
							HRS	MINS	YES	NO		
WFX 1234	09/1000	WU	09/1003	09/1020	09/1240	CB	2	20	X		WL	BELT BROKEN
WFX 1234	12/0905	WU	12/0907	12/0920	12/1450	JB	5	10	X		AS	APPEARS TO BE REC UNIT
WFX 1234	15/0800	WU	15/0803	15/0810	15/0840	JA		07		X	AS	LINE OUTAGE

AWS FORM DEC 68 42 PREVIOUS EDITION OF THIS FORM MAY BE USED 25-27

Figure 50. AWS Form 42.

comparisons 11 through 120 and again computed 5 days later using comparisons 11 through 130. How long should you make daily comparisons? For at least 8 weeks. After this span of time and if during the last 10 consecutive days no column 14B entry has exceeded the ±.010 inch or ±0.3 mb limits, you may finally consider the aneroid reliable. From this point, discontinue the daily comparisons and begin weekly comparisons.

9-21. The weekly comparisons are intended to keep the aneroid correction current. When you begin the routine weekly readings, sum the latest two readings with those made 7, 14, 21, and 28 days ago. Figure 49 shows this was done on 2/25. Further down on figure 49, comparison 135 makes an interesting comment. The comparison was disregarded because the correction was −.012, much larger than usual, and exceeds the limit for one reading. Corrections this large should be immediately verified. This was done on our sample at 0610, and a more reasonable difference of ±.001 prevailed. Keep the completed AWS Form 85 on file at the station until the aneroid is replaced.

9-22. *Communication Outage Log (AWS Form 42).* This sample form is used by all AWS stations for documenting communications outages. Time of initial notification of a deficiency to your supporting agency and all followup calls and status checks are recorded on this form. Figure 50 is an example extract AWS Form 42. The form is designed for use on the basis of one form per machine/circuit or one form for all machine/circuits per location.

9-23. Report circuit and/or equipment outages to the appropriate maintenance agency as soon as possible. AWS units report to the local AFCS unit when they are located together. If they are not, the AWS unit should notify the local maintenance agency concerned and the appropriate AFCS Communication Area.

9-24. The local AFCS unit or Communication Area is responsible for followup reports after it has been notified of an outage. Notify either the local AFCS unit or the unit responsible for area communications when service is restored and also record it on AWS Form 42.

9-25. **Maintenance.** Most weather stations have weather equipment repairmen/technicians assigned to them. These men have received maintenance training on ground meteorological equipment and perform intermediate maintenance on the equipment. Maintenance capability is determined by the skill level of the assigned 302X0 personnel. It is likely that there will be 3-, 5-, or 7-skill level personnel on hand. *Intermediate maintenance* is broken down into the following two areas:

- Preventive maintenance.
- Corrective maintenance.

9-26. Preventive maintenance routines for ground meteorological equipment are normally prepared and published by AFLC as –6 work cards, and are available through normal TO distribution channels. AWS publishes –6 work cards for minor equipment used by AWS and for equipment for which AFLC has not prepared work cards. These cards show the minimum maintenance requirements and maximum interval between performance of each routine. At locations where only one maintenance technician is assigned, the detachment commander insures that at least *one weather observer* is trained to do the daily routine work from the –6 cards.

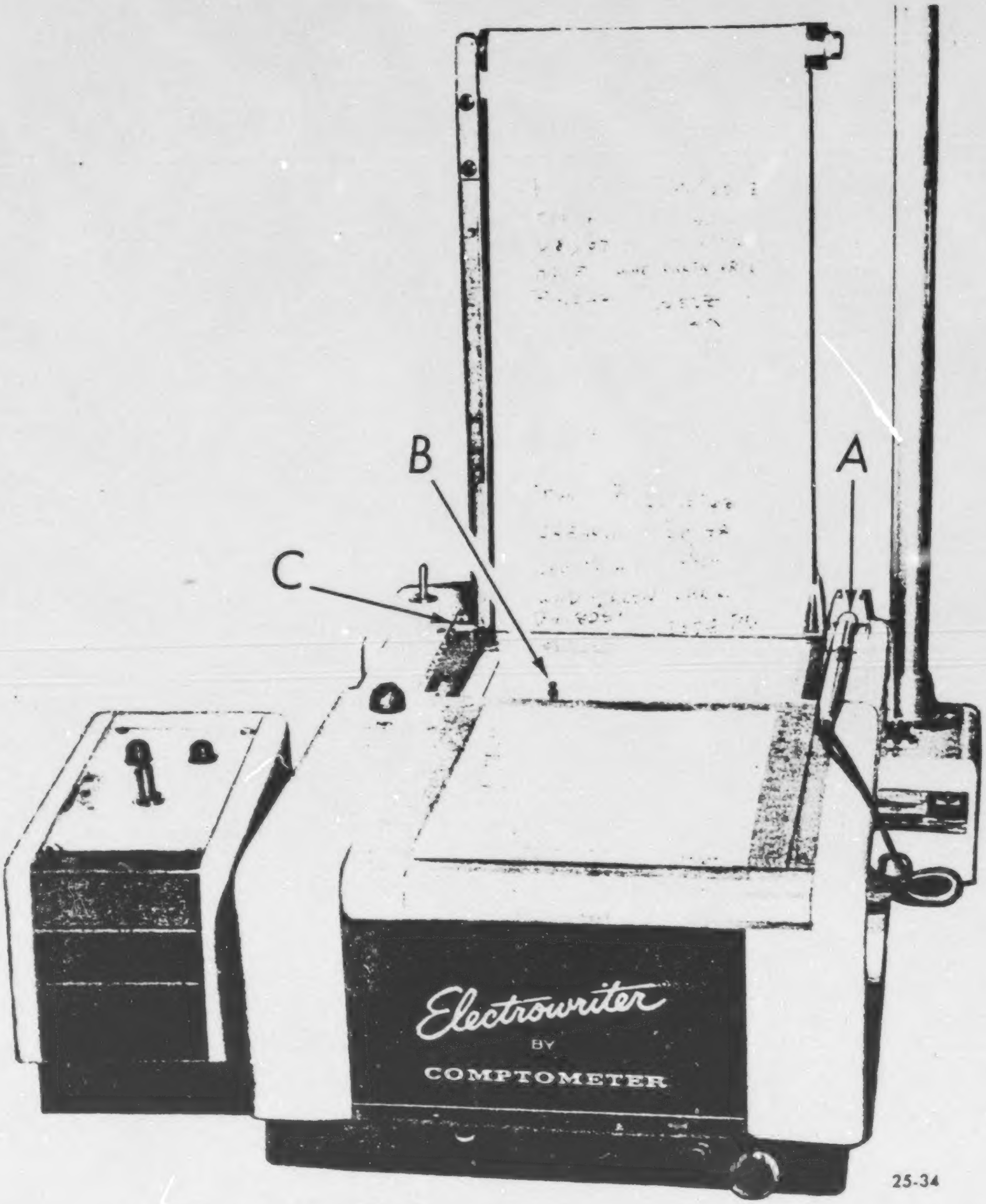
9-27. Corrective maintenance is a series of checks and repair actions required to return a malfunctioning system to operation. It involves the use of tools, test equipment, technical orders, and troubleshooting procedures. Corrective maintenance is done only by qualified weather equipment maintenance personnel.

9-28. Units that have tactical equipment in standby status should perform preventive maintenance on a quarterly basis. When local conditions warrant, preventive maintenance may be required more often.

9-29. Major maintenance and operational problems are the concern of the maintenance section. There are, however, many minor operational problems that can be solved by the observer if he knows what to do. Although the situations chosen for discussion do not exhaust the list of problems, they are typical of what can happen. In many cases the problem and solution seem absurdly simple.

9-30. Suppose the transmissometer recorder seems to be out of order. Upon checking, you find that the recorder operated properly before someone changed the chart. But now the chart does not move, even though the power is on. Furthermore, the clock is not ticking. Your first thought is that the clock has run down, so you wind the clock. But this doesn't remedy the trouble. Then you realize that changing the chart may be the key to the situation. When the chart drive lever is pushed to STOP, this lever also turns the clock mechanism off. The chart drive lever is in such a position that if the paper is changed carelessly, the lever could unintentionally be bumped to the STOP position. A glance at the position of the lever convinces you that this is the cause of the trouble.

9-31. If you are careless, changing the chart on a recording instrument such as the transmissometer, barograph, or wind recorder may cause trouble. We already mentioned the problem created by accidentally shifting the chart drive lever on the transmissometer. A chart movement switch on the wind recorder can cause a similar problem. Even though you know that power is reaching the recorder because the lights are on, the chart reel won't move unless the chart movement switch is ON. Sometimes this minor point is overlooked. Other reasons may also cause the reel not to operate. For example, if the gear end of the takeup reel is not meshed properly, when you change the chart, the reel will bind. Improperly meshed gears can be a problem on the microbarograph, too.

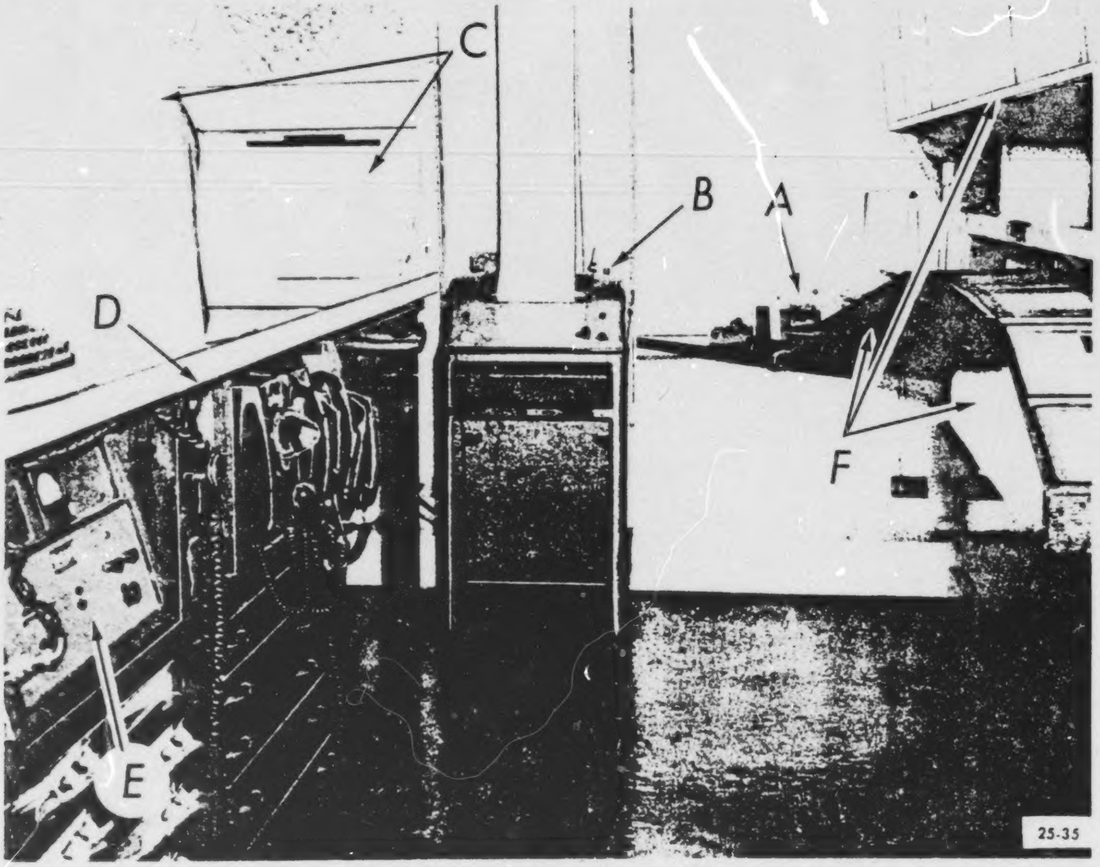


A. CONTROL PEN. B. WRITING UNIT. C. PAPER FEED CONTACT.

Figure 51. Electrowriter for local dissemination.

9-32. After replacing a chart on the barograph, you lower the chart cylinder upon the clock mechanism drive gear. Simply lowering the cylinder does not always mesh the gears. Often you must gently rotate the cylinder to mesh the gears. You know that the gears are meshed when you feel a slight drop of the cylinder. Not strictly involved with chart replacement, but easily overlooked, is the task of moving the chart clip on the cylinder past the pen on the fourth day of use. Failure to move the cylinder results in a large time error as the pen crosses the chart clip. Moving the cylinder requires unmeshing the gears, and again you must be alert to the possibility of improperly meshed gears.

9-33. Proper care of the psychrometer involves keeping the thermometer tubes and the backplate clean. Wipe them with a moist cloth to remove any dust or dirt on the instrument surfaces. The wick of the wet-bulb thermometer tends to collect dirt and dust since the moistening process attracts these particles. Remove the wick and replace it periodically to insure correct wet-bulb temperature readings. Tie the wick securely over the thermometer bulb so that the wick has a smooth surface. At times the thermometers become difficult to read because the blacking in the etching wears away. When this occurs, remove the blacking and apply new ivory black. First, carefully remove the thermometers from the metal backing. Clean the old blacking from the thermometer with turpentine or other suitable oil paint solvent. Use a pointed stick covered with cloth to remove the old blacking from the etched temperature markings. Wipe the turpentine from the surface until it is dry. Apply fresh ivory black along the entire etched surface of the thermometer tube pressing the black into the etch marks. Wipe excess ivory black from the tube and check to see that all etch marks are filled with the new blacking. After the ivory black sets and dries, refasten the thermometer tubes to the metal backing plate. Fit the small glass hook at the top of the tube into the hole of the metal backing plate



A. ELECTROWRITER.
B. COMET I RECEIVING TELETYPE.
C. BRIEFING AND DISPLAY BOARDS.
D. TELEPHONE AND INTERCOM POSITION.
E. PILOT-TO-FORECASTER RADIO.
F. ADDITIONAL TELETYPE AND FACSIMILE DISPLAYS.

Figure 52. Briefing and communications area.

before fully tightening the screws of the clamping brackets.

9-34. To maintain the rain gage, keep the overflow can, measuring tube, and collector funnel clean and free from oxidation. Do this monthly by cleaning them with copper cleaner and/or fine steel wool. Paint the tripod stand whenever necessary. Check the measuring tube for dents since this alters the volume of the tube. Pour water into the overflow can to check it for leakage.

9-35. Perhaps this brief discussion will help you with similar problems in the future. The next topic—one often taken for granted—is communications and copying equipment.

10. Communications and Copying Equipment

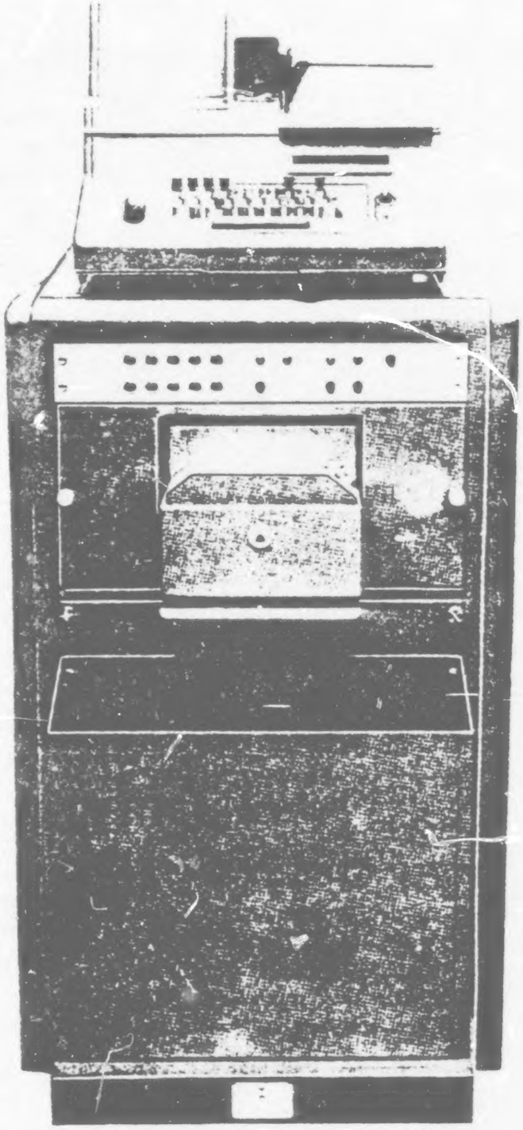
10-1. A completely accurate and representative observation is a very *perishable* item. It has little value if it is not relayed to its users while it is still current. This is one of many reasons why programs and equipment are continuously modernized. In this section we are going to discuss communications and copying equipment used to relay all types of perishable meteorological data and associated information.

10-2. **Local Communications Devices.** Various military organizations located on your base need your weather observations immediately as you complete them. The communications systems that can be used to transmit observations are:

- Autographic transcribers.
- Intercommunications (intercom) system.
- Telephone.
- Tape recording devices.
- Pony circuit.
- Weathervision.

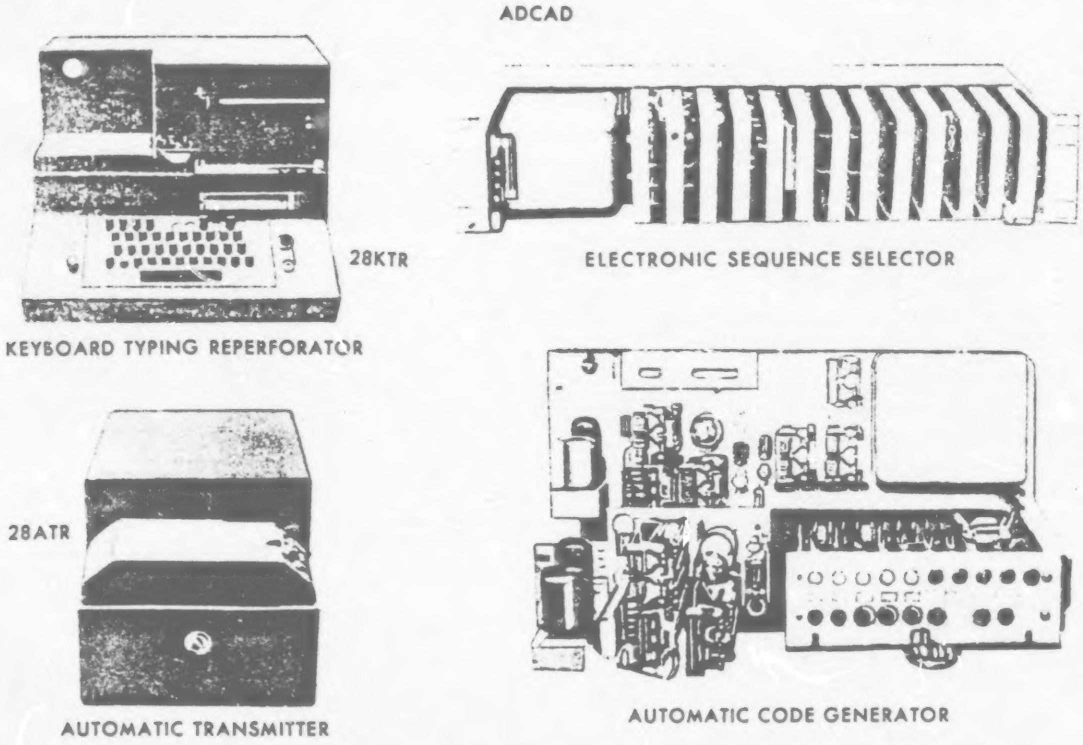
10-3. *Autographic transcribers.* The two most commonly used autographic systems are Electrowriter and Telautograph. Figure 51 shows an Electrowriter that some weather stations use to locally disseminate observations. This Electrowriter and similar models are electronic writing systems connecting two or more writing or receiving units. Refer to figure 51 again. The control pen (A) is used to move the writing unit (B) and to write the message on the paper roll. When the control pen and writing unit are in contact, they energize circuits that cause the other units to reproduce the message that is being sent from the originator. When the message is complete, the pen unit is moved to touch the paper feed contact (C); this moves the paper up to the display position of the Electrowriter.

10-4. Some weather stations use the Telautograph to disseminate their observations locally. The Telautograph is available in two models. One model operates almost exactly like the Electrowriter; the other model differs in that the control pen moves across a metal plate adjacent to the writing surface. With either the Electrowriter or Telautograph, the weather observations are received as you are writing; therefore, there is no time lag. In using the sets, write large enough so that the weather observation can be seen at a distance. Always use symbols carefully. Otherwise they may be misinterpreted by the user. Each weather station or unit has a DOI giving the exact details and format for dissemination of weather data.



25-38

Figure 53. ADCAD sending position.



OUTSTANDING EQUIPMENT AND FEATURES FOR THESE NETWORKS HAVE BEEN SPECIALLY DESIGNED TO OPERATE IN CONJUNCTION WITH THE PROGRAMMER. 25—39

Figure 54. Component parts of ADCAD system.

10-5. The autographic transcriber has some advantages over other local weather dissemination systems. The main advantage is that each receiving unit (control tower, GCA, and others) receives a permanent record of your observation as you write it. This allows the user to evaluate the incoming observations at his own convenience; he does not have to make an immediate verbal response (as when the telephone is used) when he may be busy with other tasks. Occasionally, your Electrowriter or Telautograph equipment requires maintenance; this could require an alternate method for local dissemination.

10-6. *Intercommunications system.* The use of the intercommunications system varies with observing assignments. In some remote areas of the world, the intercom is the primary method of disseminating weather observations locally. Similar to the Electrowriter system, the intercom system has receivers at all using agencies. Since the method of communication is oral, you must know the standard voice communication procedures.

10-7. When using the intercom system, speak clearly and slowly to ensure that the receiver understands the message. Most intercoms contain some background noise; therefore, speed irregularities are amplified. Perhaps this is why many weather personnel refer to the intercom as the "squawk box." AWSR 105-12, *AWS Pilot-to-Forecaster Program,* which deals with words and phrases used in communicating with pilots in flight, provides many fine examples of how to communicate weather observations effectively over radio devices. An example of this is the voice relay of an altimeter setting value. An altimeter setting of 29.92 inches of mercury is spoken as "ALTIMETER TWO NINER NINER TWO."

10-8. Because it is possible to misunderstand oral communications, all stations require the recipient to read back the observation data. Following the readback, log the actual time that you disseminated your observation and the initials of the recipient on AWS Form 40. After you have done this, check the position of the intercom switch to be sure that it is not in the SPEAK position. If the switch is left in this position, you will not be able to receive incoming calls.

10-9. *Telephone.* The telephone is probably the most widely used and most versatile means of communication that the observer has. In some remote areas of the world, the telephone is the only instrument used for disseminating weather information. This is the situation at many Southeast Asia weather sites. Regardless of your duty assignment, you should realize the importance of having telephones for either backup or, in some cases, as the primary means of local dissemination. Some telephones are installed as direct hookups to the user. These installations are called "hot lines." As the duty observer, you must be sure that official telephones are not used indiscriminately. The reason should be obvious from the following example. Suppose the control tower needs to contact you on the telephone because the tower Electrowriter is inoperative. If the backup phone is being used for unofficial business, the tower may be unable to reach you. Not only do you impair the effectiveness of the tower personnel, but you fail to provide the local weather service when it is needed.

10-10. *Tape recording devices.* At many overseas locations, where autographic systems are not practical, a voice recording system for local dissemination of observations is widely used. The system consists of a recording device employing either tape, drums, or discs, upon which the latest observations are recorded. Recipients are notified that a new observation has been recorded by a buzzer warning activated by the ROS observer. Receivers are simply direct-line telephone units, which activate the playback of the recording when the phone is lifted from the cradle. An additional "readout" is possible by dialing into the system on the regular base telephone lines.

10-11. *Pony circuit.* At some locations, the weather observation is disseminated locally by means of teletype equipment. The ROS teletype is either operated manually or is equipped with a tape transmitter for local dissemination. In either case, all using agencies receive the observation simultaneously. As you can see, the observer has available a combination of communications devices to ensure that his latest weather observation reaches the using locations. There are other methods for local dissemination of weather information;

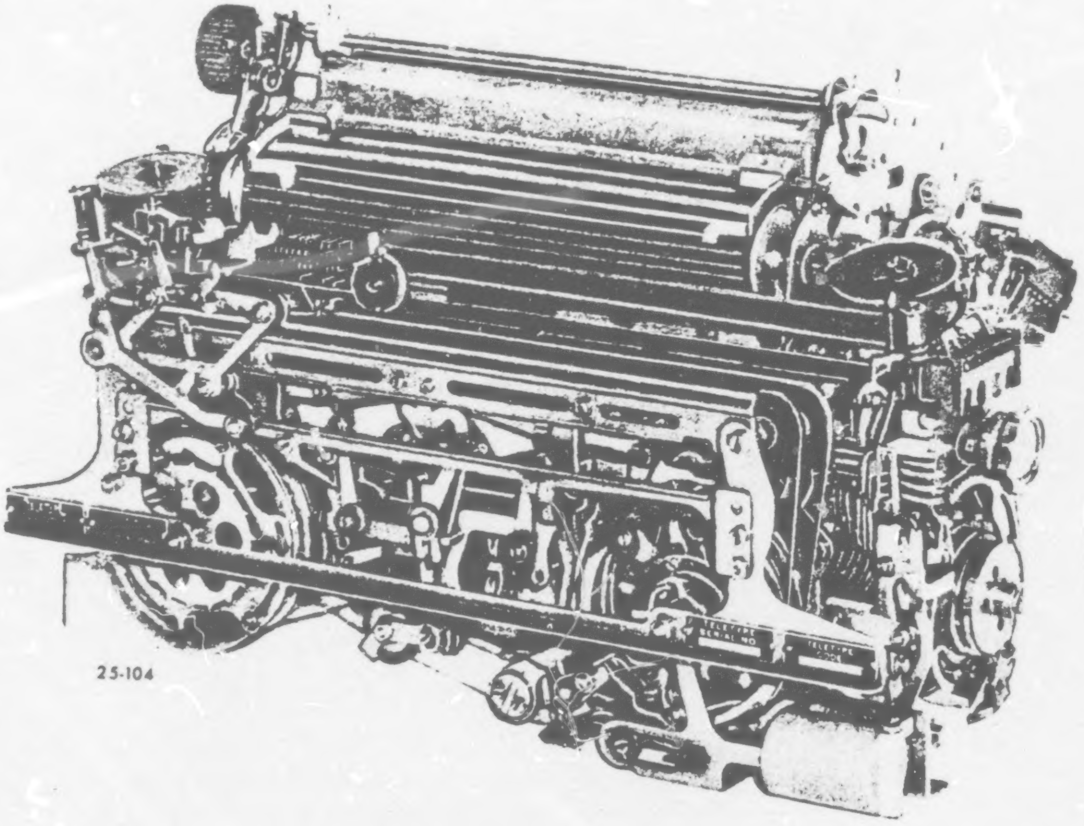


Figure 55. 28ASR page typing unit.

however, since they fall more within the area of forecasting they are discussed from this viewpoint.

10-12. *Weathervision.* Closed circuit television is used at some activities by the forecaster to disseminate weather locally. It is actually a combination visual-voice system. Weathervision is normally used by the forecaster to brief aircrews. This includes the latest local weather as well as forecasts for routes, areas, and terminals. Weathervision is becoming more widely used in presenting weather briefings. It is your responsibility to provide the forecaster with the latest local observation data for these briefings to be effective.

10-13. One of the most important local communications services that the forecaster uses is the pilot to forecaster service (PFSV) facility. This facility allows direct radio contact between the forecaster and the pilot in the cockpit. Frequently, the forecaster relays your latest observation to the pilot by this PFSV facility. This use of your observation is only one of the reasons that it has a high dissemination priority. The forecaster also uses the PFSV facility to relay local forecast data and other data of concern to the pilot. The PFSV is located near the weather data readouts and displays for easy reference.

10-14. Figure 52 shows the functional arrangement of the various readouts, displays, and communications systems forming a composite, operational briefing area. The forecaster briefs flight personnel across the counter between the two opposing facsimile displays indicated by item C. From his briefing position, the forecaster is a step or two from his sources of operational data: the Electrowriter (A), the COMET I teletype printer (B), the facsimile displays (C), the telephone and

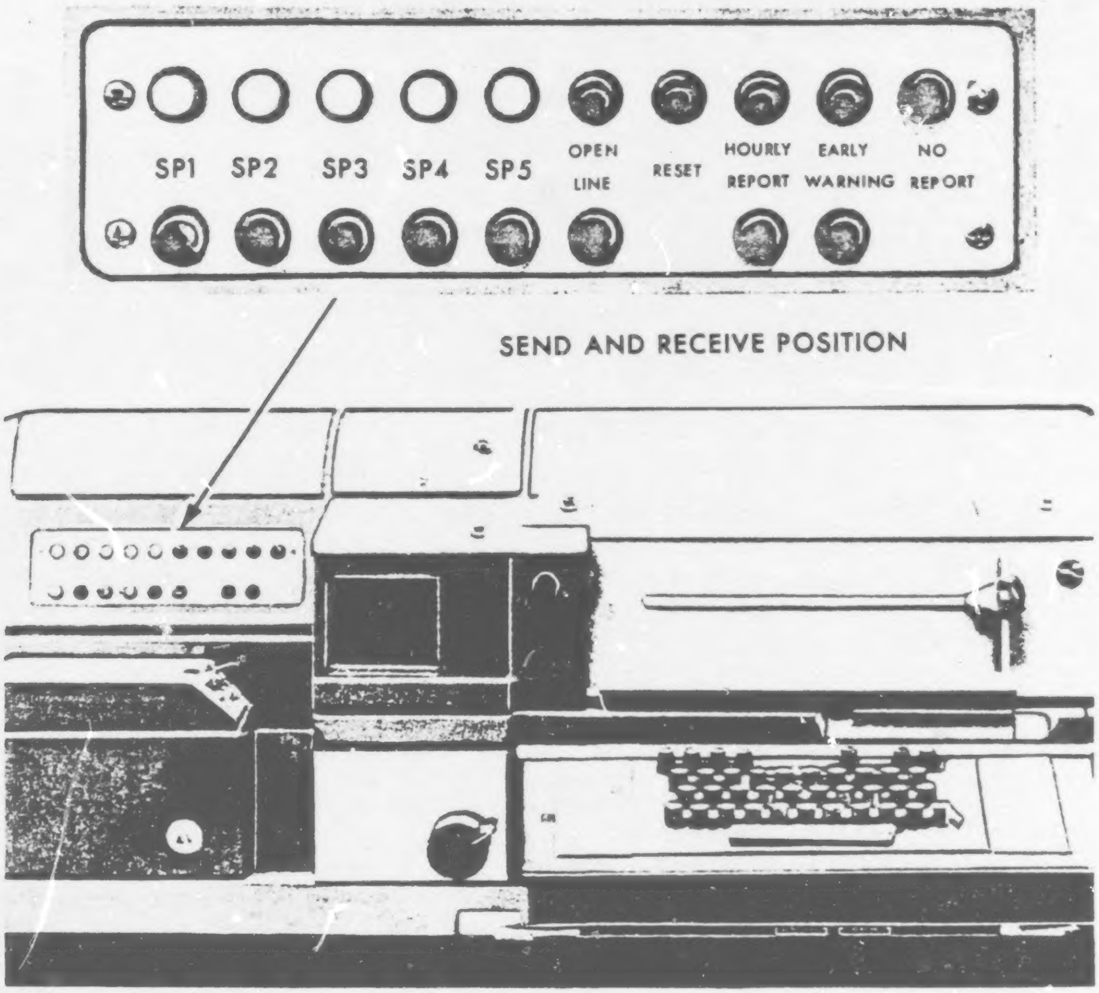


Figure 56. OWS send-receive teletype position.

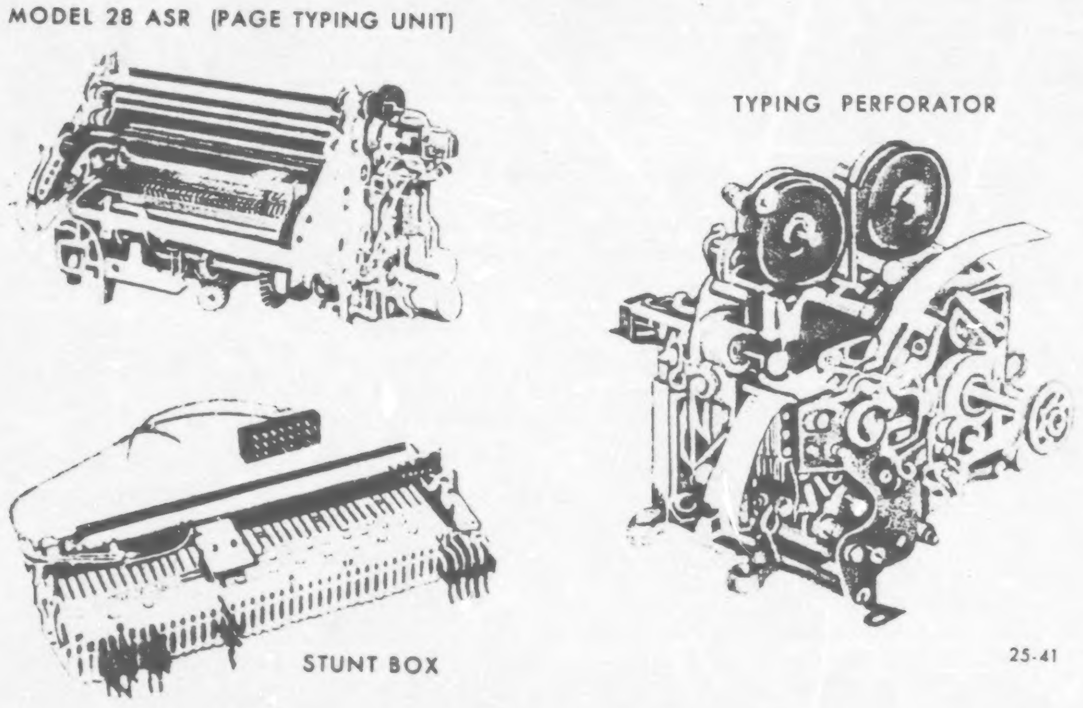


Figure 57. Component parts of OWS system.

intercom located beneath the counter (D), the PFSV radio (E), and additional teletype and facsimile displays (F) containing data that he depends upon you to post upon receipt. Note that the telephones and PFSV microphone are equipped with long. flexible cords so that the forecaster can refer to the data sources without interrupting his conversation. The operational needs of the forecaster, however, are not the only ones you serve. Other reports may be required by units served by your local detachment.

10-15. **Teletype.** At most AWS assignments, your duties include the daily handling and transmission of weather data over weather teletype circuits. Longline dissemination of weather data between military weather stations in the United States is done by an automatic collection-dissemination system. At a typical weather detachment, you can expect to transmit surface observations, pilot reports, radar reports, and terminal forecasts over weather teletype circuits. In addition, the forecaster relies heavily upon you to correctly decode, edit, and post the latest weather data that is received over weather communication circuits.

10-16. These tasks which contribute to the timeliness of forcaster products, are essential to the operational effectiveness of your unit. You are a keyman in this handling of weather data.

10-17. There are *four* major units that makeup teletype equipment in the weather station for sending and/or receiving weather data. These are combined in the airways data collection and distribution (ADCAD) (send-receive); the receiving teletype (28ASR page typing unit); the operational weather support (OWS) (send-receive); and the Model 311, Electronic Weather Data Printer.

10-18. The first, usually located at the ROS, is the ADCAD sending unit. This is used to transmit the current weather observation to the relay center where it is relayed to all sections of the United States and selected sections of the world. Figure 53 gives you a complete picture of the assembled unit. This unit includes the following four component units.

- Keyboard typing reperforator (28KTR).
- Automatic transmitter (28ATR).
- Electronic sequence selector.
- Automatic code generator.

These units are pictured in figure 54.

10-19. The receiving teletype is the second major unit of teletype equipment. It is located in the weather station (usually near the forecaster). The receiving teletype prints the observations as they are received from ADCAD positions. The Comet I receiving teletype is shown in figure 52,B. This unit consists primarily of one component

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commonly called a model 28ASR page typing unit, shown in figure 55.

10-20. The third major unit of teletype equipment that you'll be using is the operational weather support (OWS) send and receive position. This unit is usually located in the communications room of the weather station. Figure 56 gives you a complete picture of the whole unit (28ASR OWS). The OWS send and receive position consists of the following:

- Page typing unit (28ASR).
- Typing perforator.
- Stunt box.

Figure 57 illustrates these components.

10-21. You transmit all other meteorological data such as pilot reports (PIREPs), forecasts, radar weather reports (RAREPs), etc., on the OWS unit. This unit has a feature that leaves you free to do other duties in the weather stations: a series of four buttons from which you select the type of weather information you want to transmit. After you have selected and inserted the data you want to transmit, your tape will not transmit until the proper bulletin is scanned. Suppose, for example, that your RAREP is on tape. In this case you would insert the tape and then select and depress the SP–1 button. You can now turn your attention to other duties because your RAREP will be transmitted. If you were preparing terminal airdrome forecasts (TAFs) or plain language airdrome terminal forecasts (PLATFs), you would select the SP–2 button.

Figure 58 has been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Figure 58 was copyrighted and could not be duplicated.

10-22. The fourth major unit of communications equipment is a Model 311, Electronic Weather Data Printer. This equipment only *receives* data and prints it at 375 words per minute. Figure 58 is an example of the model 311 printer. Like the other equipment, it is usually located in the communications room of the weather station. The information received from this printer on the Comet III circuit is continually being upgraded with weather information such as overseas data, PIBALS, RAWINSONDE DATA, etc. In addition to the weather teletype equipment, you should know about the weather facsimile equipment and its operation.

10-23. **Facsimile.** The weather maps and charts received by facsimile recorders are valuable aids for the weather forecaster. Charts provide the forecaster with the latest analyses for large areas of the world. Observing and forecasting teams located at weather centrals prepare the various charts and analyses that are necessary to provide weather support for their area of responsibility.

10-24. Most weather activities that receive facsimile transmissions have either the RJ3 or RJ4 facsimile recorder. Figure 59 shows an RJ3 facsimile recorder. The RJ4 is similar to the RJ3 except for the type of recording paper and the process of producing the image on the chart. In addition to the facsimile recorder, most weather stations have a satellite recorder. Figure 60 is an illustration of the recorder and its major components. The name of the recorder describes the use of the machine. Its functon is to record weather pictures transmitted by satellites.

10-25. **Copying Equipment.** There are various types of copying equipment provided at weather units. Many are the office copy machine type, known by various trade names; however, some are larger machines of the type used to reproduce blueprints. The ozalid machine, shown in figure 61, is very common in a weather station because it can reproduce most any weather data such as facsimile charts, teletype data, and other large products.

10-26. Figure 61 also shows some of the main units of an ozalid streamliner 200; cabinet (A), speed adjustment knob (B), ammonia supply bot-

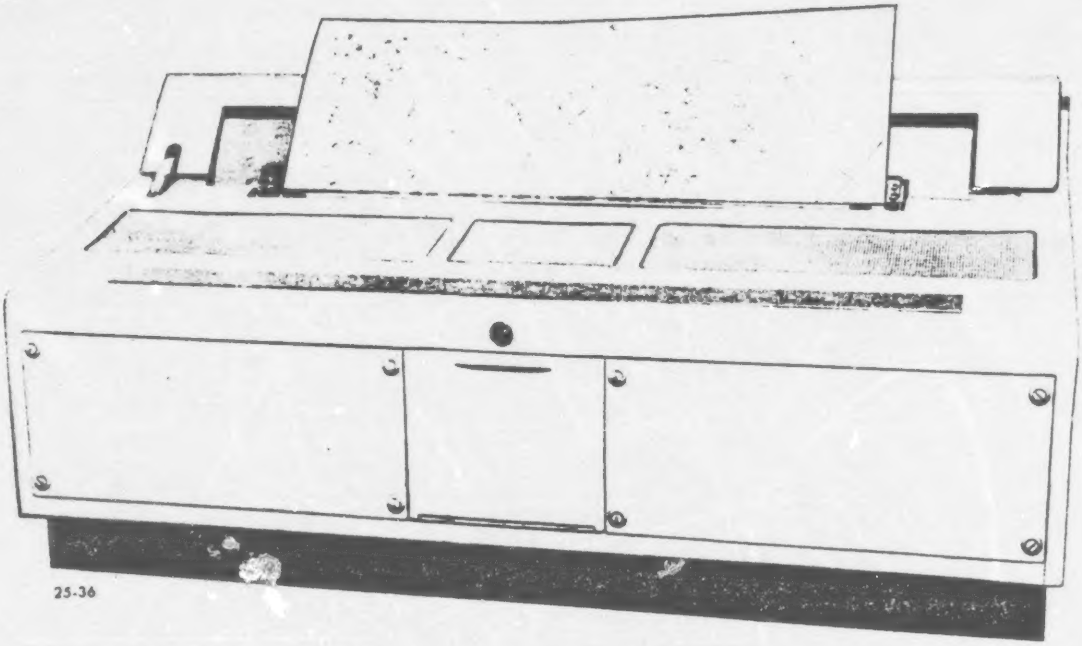

Figure 59. RJ3 facsimile recorder.

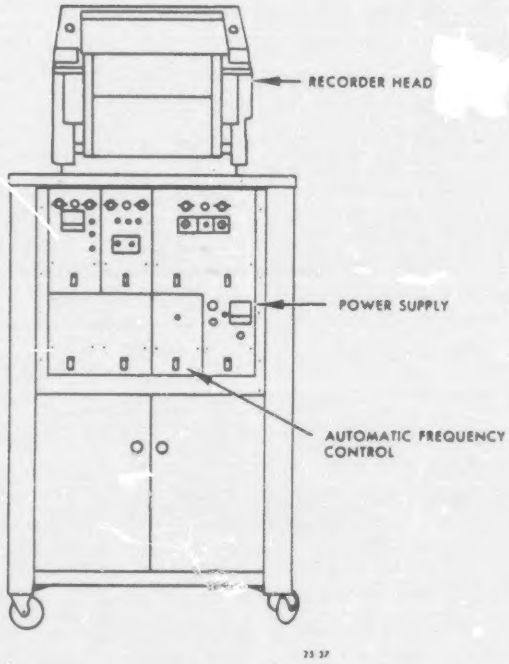
RECORDER HEAD
POWER SUPPLY
AUTOMATIC FREQUENCY CONTROL
25 37

Figure 60. Satellite recorder.

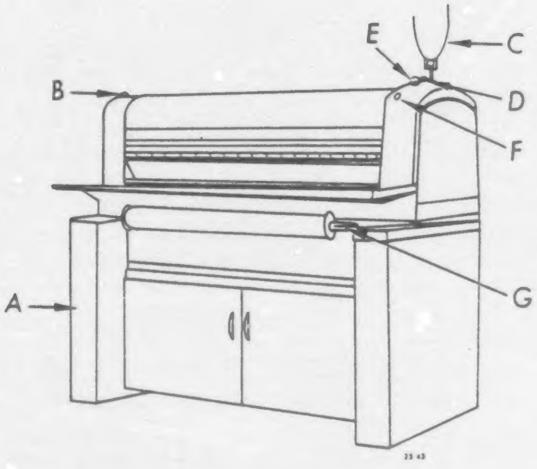
E
C
B
D
F
G
A
25 43

Figure 61. Ozalid streamliner copier.

tle (C), main switch (D), ammonia feed valve (E), drip gauge glass (F), and paper roll (G). Ammonia is very toxic. To avoid injury, follow the operating instructions for use of this equipment.

10-27. Before continuing on to Volume 2, turn to your workbook and answer the chapter review exercises on Sections 8, 9, and 10.

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NOTE: None of the items listed in the bibliography above are available through ECI. If you cannot borrow them from local sources, such as your base library or local library, you may request one item at a time on a loan basis from the AU Library, Maxwell AFB, Alabama, ATTN: ECI Bibliographic Assistant. However, the AU Library generally lends only *books* and a limited number of *AFMs*. TOs, classified publications, and other types of publications are *not* available. (For complete procedures and restrictions on borrowing materials from the AU Library, see the latest edition of the *ECI Catalog*.)

APPENDIXES

Appendix A. Standard Atmosphere Table

Appendix B. Trigonometric Functions

Appendix A

Standard Atmosphere Table in Accordance With Specifications of ICAO (International Civil Aviation Organization)

Tabular values give altitude (in feet) in the standard atmosphere as a function of pressure (inches of mercury, shown as side and top argument).
Note: Altitudes are strictly in terms of "standard geopotential feet."

Pressure, inches of mercury	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.
25.0	4888	4878	4867	4856	4846	4835	4824	4814	4803	4792
25.1	4782	4771	4760	4750	4729	4728	4718	4707	4696	4686
25.2	4675	4665	4654	4643	4633	4622	4611	4601	4590	4580
25.3	4569	4559	4548	4537	4527	4516	4506	4495	4484	4474
25.4	4463	4453	4442	4432	4421	4411	4400	4389	4379	4368
25.5	4358	4347	4337	4326	4316	4305	4295	4284	4274	4263
25.6	4253	4242	4232	4221	4211	4200	4190	4179	4169	4158
25.7	4148	4138	4127	4117	4106	4096	4085	4075	4064	4054
25.8	4044	4033	4023	4012	4002	3991	3981	3971	3960	3950
25.9	3939	3929	3919	3908	3898	3888	3877	3867	3856	3846
26.0	3836	3825	3815	3805	3794	3784	3774	3763	3753	3743
26.1	3732	3722	3712	3701	3691	3681	3670	3660	3650	3639
26.2	3629	3619	3608	3598	3588	3578	3567	3557	3547	3537
26.3	3526	3516	3506	3495	3485	3475	3465	3454	3444	3434
26.4	3424	3414	3403	3393	3383	3373	3362	3352	3342	3332
26.5	3322	3311	3301	3291	3281	3271	3260	3250	3240	3230
26.6	3220	3210	3199	3189	3179	3169	3159	3149	3138	3128
26.7	3118	3108	3098	3088	3078	3067	3057	3047	3037	3027
26.8	3017	3007	2997	2987	2976	2966	2956	2946	2936	2926
26.9	2916	2906	2896	2886	2876	2866	2855	2845	2835	2825
27.0	2815	2805	2795	2785	2775	2765	2755	2745	2735	2725
27.1	2715	2705	2695	2685	2675	2665	2655	2645	2635	2625
27.2	2615	2605	2595	2585	2575	2565	2555	2545	2535	2525
27.3	2515	2505	2495	2485	2475	2465	2455	2445	2435	2426
27.4	2416	2406	2396	2386	2376	2366	2356	2346	2336	2326
27.5	2316	2307	2297	2287	2277	2267	2257	2247	2237	2227
27.6	2218	2208	2198	2188	2178	2168	2158	2148	2139	2129
27.7	2119	2109	2099	2089	2080	2070	2060	2050	2040	2030
27.8	2021	2011	2001	1991	1981	1972	1962	1952	1942	1932
27.9	1923	1913	1903	1893	1884	1874	1864	1854	1844	1835
28.0	1825	1815	1805	1796	1786	1776	1766	1757	1747	1737
28.1	1727	1718	1708	1698	1689	1679	1669	1659	1650	1640
28.2	1630	1621	1611	1601	1592	1582	1572	1562	1553	1543
28.3	1533	1524	1514	1504	1495	1485	1475	1466	1456	1446
28.4	1437	1427	1417	1408	1398	1389	1379	1369	1360	1350
28.5	1340	1331	1321	1312	1302	1292	1283	1273	1264	1254
28.6	1244	1235	1225	1216	1206	1196	1187	1177	1168	1158
28.7	1149	1139	1129	1120	1110	1101	1091	1082	1072	1063
28.8	1053	1044	1034	1024	1015	1005	996	986	977	967
28.9	958	948	939	929	920	910	901	891	882	872
29.0	863	853	844	834	825	815	806	796	787	778
29.1	768	759	749	740	730	721	711	702	693	683
29.2	674	664	655	645	636	627	617	608	598	589
29.3	579	570	561	551	542	532	523	514	504	495
29.4	486	476	467	457	448	439	429	420	411	401
29.5	392	382	373	364	354	345	336	326	317	308
29.6	298	289	280	270	261	252	242	233	224	215
29.7	205	196	187	177	168	159	149	140	131	122
29.8	112	103	94	85	75	66	57	47	38	29
29.9	20	10	1	−8	−17	−27	−36	−45	−54	−64

Appendix B

TRIGONOMETRIC FUNCTIONS

Angles	Sines		Cosines		Tangents		Cotangents		Angle
	Nat.	Log.	Nat.	Log.	Nat.	Log.	Nat.	Log.	
0° 00′	.0000	∞	1.0000	0.0000	.0000	∞	∞	∞	90° 00′
10	.0029	7.4637	1.0000	0000	.0029	7.4637	343.77	2.5363	50
20	.0058	7648	1.0000	0000	.0058	7648	171.89	2352	40
30	.0087	9408	1.0000	0000	.0087	9409	114.59	0591	30
40	.0116	8.0658	.9999	0000	.0116	8.0658	85.940	1.9342	20
50	.0145	1627	.9999	0000	.0145	1627	68.750	8373	10
1° 00′	.0175	8.2419	.9998	9.9999	.0175	8.2419	57.290	1.7581	89° 00′
10	.0204	3088	.9998	9999	.0204	3089	49.104	6911	50
20	.0233	3668	.9997	9999	.0233	3669	42.964	6331	40
30	.0262	4179	.9997	9999	.0262	4181	38.188	5819	30
40	.0291	4637	.9996	9998	.0291	4638	34.368	5362	20
50	.0320	5050	.9995	9998	.0320	5053	31.242	4947	10
2° 00′	.0349	8.5428	.9994	9.9997	.0349	8.5431	28.636	1.4569	88° 00′
10	.0378	5776	.9993	9997	.0378	5779	26.432	4221	50
20	.0407	6097	.9992	9996	.0407	6101	24.542	3899	40
30	.0436	6397	.9900	9996	.0437	6401	22.904	3599	30
40	.0465	6677	.9089	9995	.0466	6682	21.470	3318	20
50	.0494	6940	.9988	9995	.0495	6945	20.206	3055	10
3° 00′	.0523	8.7188	.9986	9.9994	.0524	8.7194	19.081	1.2806	87° 00′
10	.0552	7423	.9985	9993	.0553	7429	18.075	2571	50
20	.0581	7645	.9983	9093	.0582	7652	17.169	2348	40
30	.0610	7857	.9981	9992	.0612	7865	16.350	2135	30
40	.0640	8059	.9980	9991	.0641	8067	15.605	1933	20
50	.0669	8251	.9978	9990	.0670	8261	14.924	1739	10
4° 00′	.0698	8.8436	.9976	9.9989	.0699	8.8446	14.301	1.1554	86° 00′
10	.0727	8613	.9974	9989	.0729	8624	13.727	1376	50
20	.0756	8783	.9971	9988	.0758	8795	13.197	1205	40
30	.0785	8946	.9969	9987	.0787	8960	12.706	1040	30
40	.0814	9104	.9967	9986	.0816	9118	12.251	0882	20
50	.0843	9256	.9964	9985	.0846	9272	11.826	0728	10
5° 00′	.0872	8.9403	.9962	9.9983	.0875	8.9420	11.430	1.0580	85° 00′
10	.0901	9545	.9959	9982	.0904	9563	11.059	0437	50
20	.0929	9682	.9957	9981	.0934	9701	10.712	0299	40
30	.0958	9816	.9954	9980	.0963	9836	10.385	0164	30
40	.0987	9945	.9951	9979	.0992	9966	10.078	0034	20
50	.1016	9.0070	.9948	9977	.1022	9.0093	9.7882	0.9907	10
6° 00′	.1045	9.0192	.9945	9.9976	.1051	9.0216	9.5144	0.9784	84° 00′
10	.1074	0311	.9942	9975	.1080	0336	9.2553	9664	50
20	.1103	0426	.9939	9973	.1110	0453	9.0098	9547	40
30	.1132	0539	.9936	9972	.1139	0567	8.7769	9433	30
40	.1161	0648	.9932	9971	.1169	0678	8.5555	9322	20
50	.1190	0755	.9929	9969	.1198	0786	8.3450	9214	10
7° 00′	.1219	9.0859	.9925	9.9968	.1228	9.0891	8.1443	0.9109	83° 00′
10	.1248	0961	.9922	9966	.1257	0995	7.9530	9005	50
20	.1276	1060	.9918	9964	.1287	1096	7.7704	8904	40
30	.1305	1157	.9914	9963	.1317	1194	7.5958	8806	30
40	.1334	1252	.9911	9961	.1346	1291	7.4287	8709	20
50	.1363	1345	.9907	9959	.1376	1385	7.2687	8615	10
8° 00′	.1392	9.1436	.9903	9.9958	.1405	9.1478	7.1154	0.8522	82° 00′
10	.1421	1525	.9809	9956	.1435	1569	6.9682	8431	50
20	.1449	1612	.9804	9954	.1465	1658	6.8269	8342	40
30	.1478	1697	.9890	9952	.1495	1745	6.6912	8255	30
40	.1507	1781	.9886	9950	.1524	1831	6.5606	8169	20
50	.1536	1863	.9881	9948	.1554	1915	6.4348	8085	10
9° 00′	.1564	9.1943	.9877	9.9946	.1584	9.1997	6.3138	0.8003	81° 00′
	Nat.	Log.	Nat.	Log.	Nat.	Log.	Nat.	Log.	
Angles	Cosines		Sines		Cotangents		Tangents		Angles

Appendix B (*Continued*)

TRIGONOMETRIC FUNCTIONS

Angles	Sines		Cosines		Tangents		Cotangents		Angles
	Nat.	Log.	Nat.	Log.	Nat.	Log.	Nat.	Log.	
9° 00′	.1564	9.1943	.9877	9.9946	.1584	9.1997	6.3138	0.8003	81° 00′
10	.1593	2022	.9872	9944	.1614	2078	6.1970	7922	50
20	.1622	2100	.9868	9942	.1644	2158	6.0844	7842	40
30	.1650	2176	.9863	9940	.1673	2236	5.9758	7764	30
40	.1679	2251	.9858	9938	.1703	2313	5.8708	7687	20
50	.1708	2324	.9853	9936	.1733	2389	5.7694	7611	10
10° 00′	.1736	9.2397	.9848	9.9934	.1763	9.2463	5.6713	0.7537	80° 00′
10	.1765	2468	.9843	9931	.1793	25 6	5.5764	7464	50
20	.1794	2538	.9838	9929	.1823	2609	5.4845	7391	40
30	.1822	2606	.9833	9927	.1853	2680	5.3955	7320	30
40	.1851	2674	.9827	9924	.1883	2750	5.3093	7250	20
50	.1880	2740	.9822	9922	.1914	2819	5.2257	7181	10
11° 00′	.1908	9.2806	.9816	9.9919	.1944	9.2887	5.1446	0.7113	79° 00′
10	.1937	2870	.9811	9917	.1974	2953	5.0658	7047	50
20	.1965	2934	.9805	9914	.2004	3020	4.9894	6980	40
30	.1904	2997	.9799	9912	.2035	3085	4.9152	6915	30
40	.2022	3058	.9793	9909	.2065	3149	4.8430	6851	20
50	.2051	3119	.9787	9907	.2095	3212	4.7729	6788	10
12° 00′	.2079	9.3179	.9781	9.9904	.2126	9.3275	4.7046	0.6725	78° 00′
10	.2108	3238	.9775	9901	.2156	3336	4.6382	6664	50
20	.2136	3296	.9769	9899	.2186	3397	4.5736	6603	40
30	.2164	3353	.9763	9896	.2217	3458	4.5107	6542	30
40	.2193	3410	.9757	9893	.2247	3517	4.4494	6483	20
50	.2221	3466	.9750	9890	.2278	3576	4.3897	6424	10
13° 00′	.2250	9.3521	.9744	9.9887	.2309	9.3634	4.3315	0.6366	77° 00′
10	.2278	3575	.9737	9884	.2339	3691	4.2747	6309	50
20	.2306	3629	.9730	9881	.2370	3748	4.2193	6252	40
30	.2334	3682	.9724	9878	.2401	3804	4.1653	6196	30
40	.2363	3734	.9717	9875	.2432	3859	4.1126	6141	20
50	.2391	3786	.9710	9872	2462	3914	4.0611	6086	10
14° 00′	.2419	9.3837	.9703	9.9869	.2493	9.3968	4.0108	0.6032	76° 00′
10	.2447	3887	.9896	9866	.2524	4021	3.9617	5979	50
20	.2476	3937	.9689	9863	.2555	4074	3.9136	5926	40
30	.2504	3986	.9681	9859	.2586	4127	3.8667	5873	30
40	.2532	4035	.9674	9856	.2617	4178	3.8208	5822	20
50	.2560	4083	.9667	9853	.2648	4230	3.7760	5770	10
15° 00′	.2588	9.4130	.9659	9.9849	.2679	9.4281	3.7321	0.5719	75° 00′
10	.2616	4177	.9652	9846	.2711	4331	3.6891	5669	50
20	.2644	4223	.9644	9843	.2742	4381	3.6470	5619	40
30	.2672	4269	.9636	9839	.2773	4430	3.6059	5570	30
40	.2700	4314	.9628	9836	.2805	4479	3.5656	5521	20
50	.2728	4359	.9621	9832	.2836	4527	3.5261	5473	10
16° 00′	.2756	9.4403	.9613	9.9828	.2867	9.4575	3.4874	0.5425	74° 00
10	.2784	4447	.9605	9825	.2899	4622	3.4495	5378	50
20	.2812	4491	.9596	9821	.2931	4669	3.4124	5331	40
30	.2840	4533	.9388	9817	.2962	4716	3.3759	5284	30
40	.2868	4576	.9580	9814	.2994	4762	3.3402	5238	20
50	.2896	4618	.9572	9810	.3026	4808	3.3052	5192	10
17° 00′	.2924	9.4659	.9563	9.9806	.3057	9.4853	3.2709	0.5147	73° 00′
10	.2952	4700	.9555	9802	.3089	4898	3.2371	5102	50
20	.2979	4741	.9546	9798	.3121	4943	3.2041	5057	40
30	.3007	4781	.9537	9794	.3153	4987	3.1716	5013	30
40	.3035	4821	.9528	9790	.3185	5031	3.1397	4969	20
50	.3062	4861	.9520	9786	.3217	5075	3.1084	4925	10
18° 00′	.3090	9.4900	.9511	9.9782	.3249	9.5118	3.0777	0.4882	72° 00′
	Nat.	Log.	Nat.	Log.	Nat.	Log.	Nat.	Log.	
Angles	Cosines		Sines		Cotangents		Tangents		Angles

Appendix B (*Continued*)

TRIGONOMETRIC FUNCTIONS

Angles	Sines		Cosines		Tangents		Cotangents		Angles
	Nat.	Log.	Nat.	Log.	Nat.	Log.	Nat.	Log.	
18° 00′	.3090	9.4900	.9511	9.9782	.3249	9.5118	3.0777	0.4882	72° 00′
10	.3118	4939	.9502	9778	.3281	5161	3.0475	4839	50
20	.3145	4977	.9492	9774	.3314	5203	3.0178	4797	40
30	.3173	5015	.9483	9770	.3346	5245	2.9887	4755	30
40	.3201	5052	.9474	9765	.3378	5287	2.9600	4713	20
50	.3228	5090	.9465	9761	.3411	5329	2.9319	4671	10
19° 00′	.3256	9.5126	.9455	9.9757	.3443	9.5370	2.9042	0.4630	71° 00′
10	.3283	5163	.9446	9752	.3476	5411	2.8770	4589	50
20	.3311	5199	.9436	9748	.3508	5451	2.8502	4549	40
30	.3338	5235	.9426	9743	.3541	5491	2.8239	4509	30
40	.3365	5270	.9417	9739	.3574	5531	2.7980	4469	20
50	.3393	5306	.9407	9734	.3607	5571	2.7725	4429	10
20° 00′	.3420	9.5341	.9397	9.9730	.3640	9.5611	2.7475	0.4389	70° 00′
10	.3448	5375	.9387	9725	.3673	5650	2.7228	4350	50
20	.3475	5409	.9377	9721	.3706	5689	2.6985	4311	40
30	.3502	5443	.9367	9716	.3739	5727	2.6746	4273	30
40	.3529	5477	.9356	9711	.3772	5766	2.6511	4234	20
50	.3557	5510	.9346	9706	.3805	5804	2.6279	4196	10
21° 00′	.3584	9.5543	.9336	9.9702	.3839	9.5842	2.6051	0.4158	69° 00′
10	.3611	5576	.9325	9697	.3872	5879	2.5826	4121	50
20	.3638	5609	.9315	9692	.3906	5917	2.5605	4083	40
30	.3665	5641	.9304	9687	.3939	5954	2.5386	4046	30
40	.3692	5673	.9293	9682	.3973	5991	2.5172	4009	20
50	.3719	5704	.9283	9677	.4006	6028	2.4960	3972	10
22° 00′	.3746	9.5736	.9272	9.9672	.4040	9.6064	2.4751	0.3936	68° 00′
10	.3773	5767	.9261	9667	.4074	6100	2.4545	3900	50
20	.3800	5798	.9250	9661	.4108	6136	2.4342	3864	40
30	.3827	5828	.9239	9656	.4142	6172	2.4142	3828	30
40	.3854	5859	.9228	9651	.4176	6208	2.3945	3792	20
50	.3881	5889	.9216	9646	.4210	6243	2.3750	3757	10
23° 00′	.3907	9.5919	.9205	9.9640	.4245	9.6279	2.3559	0.3721	67° 00′
10	.3934	5948	.9194	9635	.4279	6314	2.3369	3686	50
20	.3961	5978	.9182	9629	.4314	6348	2.3183	3652	40
30	.3987	6007	.9171	9624	.4348	6383	2.2998	3617	30
40	.4014	6036	.9159	9618	.4383	6417	2.2817	3583	20
50	.4041	6065	.9147	9613	.4417	6452	2.2637	3548	10
24° 00′	.4067	9.6093	.9135	9.9607	.4452	9.6486	2.2460	0.3514	66° 00′
10	.4094	6121	.9124	9602	.4487	6520	2.2286	3480	50
20	.4120	6149	.9112	9596	.4522	6553	2.2113	3447	40
30	.4147	6177	.9100	9590	.4557	6587	2.1943	3413	30
40	.4173	6205	.9088	9584	.4592	6620	2.1775	3380	20
50	.4200	6232	.9075	9579	.4628	6654	2.1609	3346	10
25° 00′	.4226	9.6259	.9063	9.9573	.4663	9.6687	2.1445	0.3313	65° 00′
10	.4253	6286	.9051	9567	.4699	6720	2.1283	3280	50
20	.4279	6313	.9038	9561	.4734	6752	2.1123	3248	40
30	.4305	6340	.9026	9555	.4770	6785	2.0965	3215	30
40	.4331	6366	.9013	9549	.4806	6817	2.0809	3183	20
50	.4358	6392	.9001	9543	.4841	6850	2.0655	3150	10
26° 00′	.4384	9.6418	.8988	9.9537	.4877	9.6882	2.0503	0.3118	64° 00′
10	.4410	6444	.8975	9530	.4913	6914	2.0353	3086	50
20	.4436	6470	.8962	9524	.4950	6946	2.0204	3054	40
30	.4462	6495	.8949	9518	.4986	6977	2.0057	3023	30′
40	.4488	6521	.8936	9512	.5022	7009	1.9912	2991	20
50	.4514	6546	.8923	9505	.5059	7040	1.9768	2960	10
27° 00′	.4540	9.6570	.8910	9.9499	.5095	9.7072	1.9626	0.2928	63° 00′
	Nat.	Log.	Nat.	Log.	Nat.	Log.	Nat.	Log.	
Angles	Cosines		Sines		Cotangents		Tangents		Angles

Appendix B (*Continued*)

TRIGONOMETRIC FUNCTIONS

Angles	Sines		Cosines		Tangents		Cotangents		Angles
	Nat.	Log.	Nat.	Log.	Nat.	Log.	Nat.	Log.	
27° 00′	.4540	9.6570	.8910	9.9499	.5095	9.7022	1.9626	0.2928	63° 00′
10	.4566	6595	.8897	9492	.5132	7103	1.9486	2897	50
20	.4592	6620	.8884	9486	.5169	7134	1.9347	2866	40
30	.4617	6644	.8870	9479	.5206	7165	1.9210	2835	30
40	.4643	6668	.8857	9473	.5243	7196	1.9074	2804	20
50	.4669	6692	.8843	9466	.5280	7226	1.8940	2774	10
28° 00′	.4695	9.6716	.8829	9.9459	.5317	9.7257	1.8807	0.2743	62° 00′
10	.4720	6740	.8816	9453	.5354	7287	1.8676	2713	50
20	.4746	6763	.8802	9446	.5392	7317	1.8546	2683	40
30	.4772	6787	.8788	9439	.5430	7348	1.8418	2652	30
40	.4797	6810	.8774	9432	.5467	7378	1.8291	2622	20
50	.4823	6833	.8760	9425	.5505	7408	1.8165	2592	10
29° 00′	.4848	9.6856	.8746	9.9418	.5543	9.7438	1.8040	0.2562	61° 00′
10	.4874	6878	.8732	9411	.5581	7467	1.7917	2533	50
20	.4899	6901	.8718	9404	.5619	7497	1.7796	2503	40
30	.4924	6923	.8704	9397	.5658	7526	1.7675	2474	30
40	.4950	6946	.8689	9390	.5696	7556	1.7556	2444	20
50	.4975	6968	.8675	9383	.5735	7585	1.7437	2415	10
30° 00′	.5000	9.6990	.8660	9.9375	.5774	9.7614	1.7321	0.2386	60° 00′
10	.5025	7012	.8646	9368	.5812	7644	1.7205	2356	50
20	.5050	7033	.8631	9361	.5851	7673	1.7090	2327	40
30	.5075	7055	.8616	9353	.5890	7701	1.6977	2299	30
40	.5100	7076	.8601	9346	.5930	7730	1.6864	2270	20
50	.5125	7097	.8587	9338	.5969	7759	1.6753	2241	10
31° 00′	.5150	9.7118	.8572	9.9331	.6009	9.7788	1.6643	0.2212	59° 00
10	.5175	7139	.8557	9323	.6048	7816	1.6534	2184	50
20	.5200	7160	.8542	9315	.6088	7845	1.6426	2155	40
30	.5225	7181	.8526	9308	.6128	7873	1.6319	2127	30
40	.5250	7201	.8511	9300	.6168	7902	1.6212	2098	20
50	.5275	7222	.8496	9292	.6208	7930	1.6107	2070	10
32° 00′	.5299	9.7242	.8480	9.9284	.6249	9.7958	1.6003	0.2042	58° 00′
10	.5324	7262	.8465	9276	.6289	7986	1.5900	2014	50
20	.5348	7282	.8450	9268	.6330	8014	1.5798	1986	40
30	.5373	7302	.8434	9260	.6371	8042	1.5697	1958	30
40	.5398	7322	.8418	9252	.6412	8070	1.5597	1930	20
50	.5422	7342	.8403	9244	.6453	8097	1.5497	1903	10
33° 00′	.5446	9.7361	.8387	9.9236	.6494	9.8125	1.5399	0.1875	57° 00
10	.5471	7380	.8371	9228	.6536	8153	1.5301	1847	50
20	.5495	7400	.8355	9219	.6577	8180	1.5204	1820	40
30	.5519	7419	.8339	9211	.6619	8208	1.5108	1792	30
40	.5544	7438	.8323	9203	.6661	8235	1.5013	1765	20
50	.5568	7457	.8307	9194	.6703	8263	1.4919	1737	10
34° 00′	.5592	9.7476	.8290	9.9186	.6745	9.8290	1.4826	0.1710	56° 00
10	.5616	7494	.8274	9177	.6787	8317	1.4733	1683	50
20	.5640	7513	.8258	9169	.6830	8344	1.4641	1656	40
30	.5664	7531	.8241	9160	.6873	8371	1.4550	1629	30
40	.5688	7550	.8225	9151	.6916	8398	1.4460	1602	20
50	.5712	7568	.8208	9142	.6959	8425	1.4370	1575	10
35° 00′	.5736	9.7586	.8192	9.9134	.7002	9.8452	1.4281	0.1548	55° 00′
10	.5760	7604	.8175	9125	.7046	8479	1.4193	1521	50
20	.5783	7622	.8158	9116	.7089	8506	1.4106	1494	40
30	.5807	7640	.8141	9107	[illegible]	8533	1.4019	1467	30
40	.5831	7657	.8124	9098	.7177	8559	1.3934	1441	20
50	.5854	7675	.8107	9089	.7221	8586	1.3848	1414	10
36° 00′	.5878	9.7692	.8090	9.9080	.7265	9.8613	1.3764	0.1387	54° 00′
	Nat.	Log.	Nat.	Log.	Nat.	Log.	Nat.	Log.	
Angles	Cosines		Sines		Cotangents		Tangents		Angles

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Appendix B (*Continued*)

TRIGONOMETRIC FUNCTIONS

Angles	Sines		Cosines		Tangents		Cotangents		Angles
	Nat.	Log.	Nat.	Log.	Nat.	Log.	Nat.	Log.	
36° 00′	.5878	9.7692	.8090	9.9080	.7265	9.8613	1.3764	0.1387	54° 00′
10	.5901	7710	.8073	9070	.7310	8639	1.3680	1361	50
20	.5925	7727	.8056	9061	.7355	8666	1.3597	1334	40
30	.5948	7744	.8039	9052	.7400	8692	1.3514	1308	30
40	.5972	7761	.8021	9042	.7445	8718	1.3432	1282	20
50	.5995	7778	.8004	9033	.7490	8745	1.3351	1255	10
37° 00′	.6018	9.7795	.7986	9.9023	.7536	9.8771	1.3270	0.1229	53° 00′
10	.6041	7811	.7969	9014	.7581	8797	1.3190	1203	50
20	.6065	7828	.7951	9004	.7627	8824	1.3111	1176	40
30	.6088	7844	.7934	8995	.7673	8850	1.3032	1150	30
40	.6111	7861	.7916	8985	.7720	8876	1.2954	1124	20
50	.6134	7877	.7898	8975	.7766	8902	1.2876	1098	10
38° 00′	.6157	9.7893	.7880	9.8965	.7813	9.8928	1.2799	0.1072	52° 00′
10	.6180	7910	.7862	8955	.7860	8954	1.2723	1046	50
20	.6202	7926	.7844	8945	.7907	8980	1.2647	1020	40
30	.6225	7941	.7826	8935	.7954	9006	1.2572	0994	30
40	.6248	7957	.7808	8925	.8002	9032	1.2497	0968	20
50	.6271	7973	.7790	8915	.8050	9058	1.2423	0942	10
39° 00′	.6293	9.7989	.7771	9.8905	.8098	9.9084	1.2349	0.0916	51° 00′
10	.6316	8004	.7753	8895	.8146	9110	1.2276	0890	50
20	.6338	8020	.7735	8884	.8195	9135	1.2203	0865	40
30	.6361	8035	.7716	8874	.8243	9161	1.2131	0839	30
40	.6383	8050	.7698	8864	.8292	9187	1.2059	0813	20
50	.6406	8066	.7679	8853	.8342	9212	1.1988	0788	10
40° 00′	.6428	9.8081	.7660	9.8843	.8391	9.9238	1.1918	0.0762	50° 00′
10	.6450	8096	.7642	8832	.8441	9264	1.1847	0736	50
20	.6472	8111	.7623	8821	.8491	9289	1.1778	0711	40
30	.6494	8125	.7604	8810	.8541	9315	1.1708	0685	30
40	.6517	8140	.7585	8800	.8591	9341	1.1640	0659	20
50	.6539	8155	.7566	8789	.8642	9366	1.1571	0634	10
41° 00′	.6561	9.8169	.7547	9.8778	.8693	9.9392	1.1504	0.0608	49° 00′
10	.6583	8184	.7528	8767	.8744	9417	1.1436	0583	50
20	.6604	8198	.7509	8756	.8796	9443	1.1369	0577	40
30	.6626	8213	.7490	8745	.8847	9468	1.1303	0532	30
40	.6648	8227	.7470	8733	.8899	9494	1.1237	0506	20
50	.6670	8241	.7451	8722	.8952	9519	1.1171	0481	10
42° 00′	.6691	9.8255	.7431	9.8711	.9004	9.9544	1.1106	0.0456	48° 00′
10	.6713	8269	.7412	8699	.9057	9570	1.1041	0430	50
20	.6734	8283	.7392	8688	.9110	9595	1.0977	0405	40
30	.6756	8297	.7373	8676	.9163	9621	1.0913	0379	30
40	.6777	8311	.7353	8665	.9217	9646	1.0850	0354	20
50	.6799	8324	.7333	8653	.9271	9671	1.0786	0329	10
43° 00′	.6820	9.8338	.7314	9.8641	.9325	9.9697	1.0724	0.0303	47° 00′
10	.6841	8351	.7294	8629	.9380	9722	1.0661	0278	50
20	.6862	8365	.7274	8618	.9435	9747	1.0599	0253	40
30	.6884	8378	.7254	8606	.9490	9772	1.0538	0228	30
40	.6905	8391	.7234	8594	.9545	9798	1.0477	0202	20
50	.6926	8405	.7214	8582	.9601	9823	1.0416	0177	10
44° 00′	.6947	9.8418	.7193	9.8569	.9657	9.9848	1.0355	0.0152	46° 00′
10	.6967	8431	.7173	8557	.9713	9874	1.0295	0126	50
20	.6988	8444	.7153	8545	.9770	9899	1.0235	0101	40
30	.7009	8457	.7133	8532	.9827	9924	1.0176	0076	30
40	.7030	8469	.7112	8520	.9884	9949	1.0117	0051	20
50	.7050	8482	.7092	8507	.9942	9975	1.0058	0025	10
45° 00′	.7071	9.8495	.7071	9.8495	1.0000	0.0000	1.0000	0.0000	45° 00′
	Nat.	Log.	Nat.	Log.	Nat.	Log.	Nat.	Log.	
Angles	Cosines		Sines		Cotangents		Tangents		Angles

AU-GAFS,ALA.(750418)1800

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MODIFICATIONS

Foldouts 1-4 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

LOCATION IDENTIFIER	TIME OF REPORT	CHARACTER OF ECHOES	WEATHER AND INTENSITY	INTENSITY TENDENCY
ABQ	1605 Z	AREA ⦷	TRW-	/+

DECODED REPORT

Kirtland AFB NM. Special observation at 1605 Z broken area of echoes containing thunderstorms producing light rain showers at the surface. These echoes are increasing in intensity. Area extends from $4^{\circ}125$ nautical miles to $221^{\circ}115$ nautical miles, is 100 nautical miles wide, moving from 270 degrees at 30 knots. Maximum top of the detectable moisture is 35,000 feet MSL. Hail 3/4 inch in diameter was reported in an echo at $310^{\circ}45$ nautical miles.

The above report is for the echo area in radarscope picture. The slash mark (/) is used to separate the intensity of the echo from the intensity tendency.

TIME OF REPORT

Time of observation (24-hour clock) in Greenwich Mean Time. Given only in observations containing hurricane data, an important change in echo pattern, or transmitted out of the SDUS scan period.

CHARACTER OF ECHOES

CHARACTER	DEFINITION	CONTRACTION
Isolated echo	Independent convective echo	CELL
Widely scattered area	An area less than 1/10 covered with echoes	AREA WDLY ⦶
Scattered area	An area 1/10 to 5/10 covered with echoes.	AREA ⦶
Broken area	An area 6/10 or more covered with echoes, but with breaks	AREA ⦷
Solid area	Contiguous echoes covering usually more than 9/10 of the reported areas.	AREA ⊕
Line of widely scattered echoes	(See widely scattered area).	LN WDLY ⦶
Line of scattered echoes	(See scattered area)	LN ⦶
Line of broken echoes	(See broken area).	LN ⦷
Solid line of echoes.	(See solid area).	LN ⊕
Spiral band area	Curved lines of echoes, including wall cloud, which occur in connection with a hurricane, tropical storm, or typhoon	SPRL BAND AREA (⦷ or ⦶)
Stratified elevated echo (⊕, ⦷ or ⦶)	Precipitation aloft	LYR (⊕, ⦷ or ⦶)
Fine line	Narrow, non precipitation echo associated with a meteorological discontinuity	FINE LN

PRECIPITATION SYMBOLS

RW	Rain Showers	T	Thunderstorms
R	Rain	ZR	Freezing Rain

INTENSITY FOR PCPN SYMBOLS ABOVE

Very Light	- -	Heavy	+
Light	-	Very Heavy	++
Moderate	No Sign	Unknown	U

PRECIPITATION SYMBOLS, NO INTENSITY SYMBOLS USED.

A	Hail	L	Drizzle
IP	Ice Pellets	S	Snow
IPW	Ice Pellet Showers	SW	Snow Showers
		ZL	Freezing Drizzle

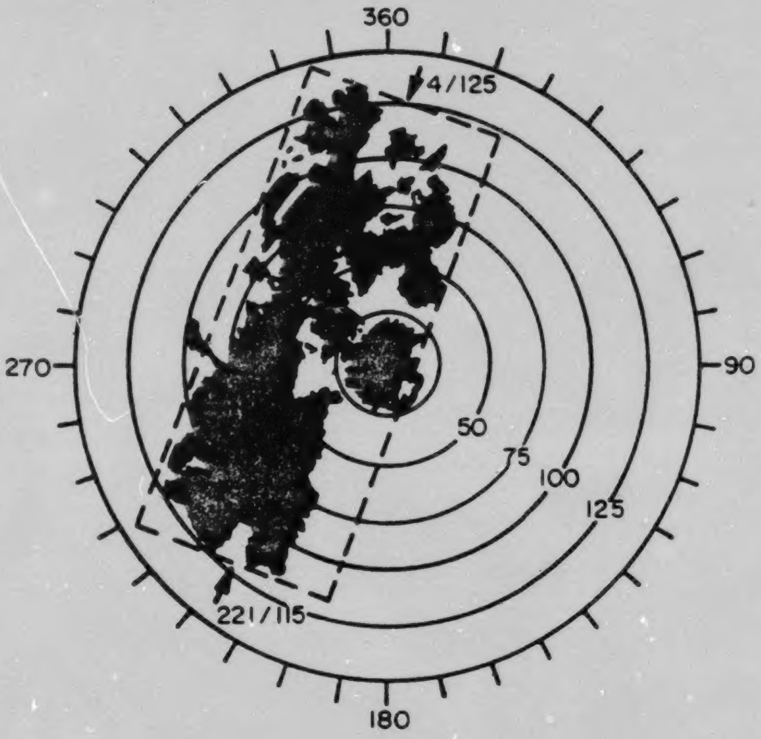
INTENSITY TREND

TREND	CONTRACTION
Increasing	+
Unchanging	NC
Decreasing	—
New	NEW
Unknown	Omit

The intensity trend is observed and evaluated in terms of the net change in the characteristic intensity during a specified period, which is one hour for lines and areas and fifteen minutes for cells.

Foldout 5

LOCATION AND DIMENSIONS OF ECHOES	MOVEMENT	ECHO TOPS
4/125 221/115 100W	2730	MAX TOP



NOTE: Echo pattern is classified as a line if its length-to-width ratio is at least 5 to 1 and its length is at least 20 miles.

DIMENSIONS OF ECHOES

Width (W) or diameter (D) are reported in nautical miles. The average width of lines and rectangular areas, and the average diameter of cells and roughly circular areas, are reported.

MOVEMENT

Direction, to nearest ten degrees from which, and speed in knots with which, the echo is moving. Both cell and system movement are reported. Line movement is reported in terms of the component perpendicular to the axis.

Foldout 5

	REMARKS
350 AT 310/45	¾ INCH HAIL 310/45

OPERATIONAL STATUS

STATUS	CONTRACTION
(1) Equipment performance normal on PPI scan; echoes not observed	PPINE
(2) Equipment out of service for preventive maintenance resulting in loss of PPI presentation.	PPIOM
* (The contraction is followed by a date-time group to indicate the estimated time when operation will be resumed.)	
(3) Observation omitted for a reason other than those above, or not available *	PPINA
(4) Radar not operating on RHI mode; echo altitude measurements not available	RHINO
(5) A-scope or A/R indicator not operating	ARNO
(6) Radar operating below performance standards	ROBEPS

A contraction pertaining to the operational status of the equipment is sent as required by the table above. In the above list, "PPI" refers to the radarscope (Plan Position Indicator); the additional letters refer to "no echo" (NE).

GENERAL NOTES

Rarep Identifier

SD (Storm Detection)--Identifies message as a weather radar observation. When the report contains an important change in echo patterns, or some other special criteria given in the Weather Radar Manual, Part A has been met, it is designated as a special (SPL).

Intensity of precipitation at distances exceeding 125 nautical miles from a FPS-77 or other radar of similar sensitivity, or 75 miles from other radars, will be reported as unknown (U). Intensities of snow, hail, drizzle, and sleet are not reported.

One rainfall intensity category is selected to characterize each reported echo system. For convective systems, it is the maximum intensity in the system. For other systems, it is the intensity predominant in horizontal extent.

Persisting echoes are indicated in remarks.

LOCATION OF ECHOES

1. Locations of echoes are relative to the radar position. The azimuth in degrees true, and the distance in nautical miles, to salient points of the echoes are given.
2. If the echoes are arranged in a line, the azimuth and distance will be given to as many points along the axis of the line as are necessary to establish its shape.
3. If an irregularly shaped area is covered by echoes, the azimuth and range to salient points on the perimeter of the area will be reported as necessary to reconstruct the shape and size of the echo area.
4. If an area of echoes of roughly circular shape is observed, or if a single echo such as a thunderstorm cell is observed, the azimuth and range to the center of the area or cell will be reported.

ECHO TOPS

Maximum height of detectable moisture, in hundreds of feet above mean sea level. Tops are not reported beyond 120 nautical mile range.

UNUSUAL ECHO FORMATIONS

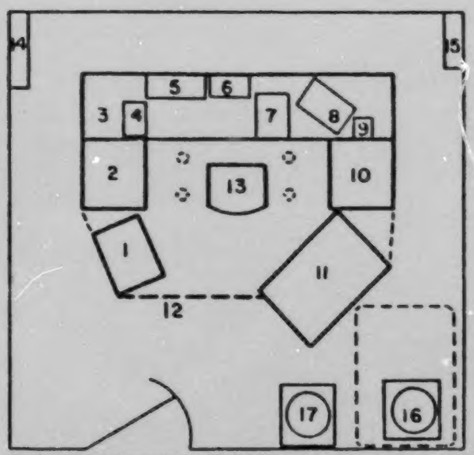
Certain types of severe storms produce distinctive patterns on the radar scope. For example, the hook-shaped echo associated with torandoes and the spiral bands with hurricanes. The bright band is a narrow horizontal layer of intensified radar signal a short distance below the 0°C isotherm (Melting level). Unusual echo formations will be reported in remarks.

25-1

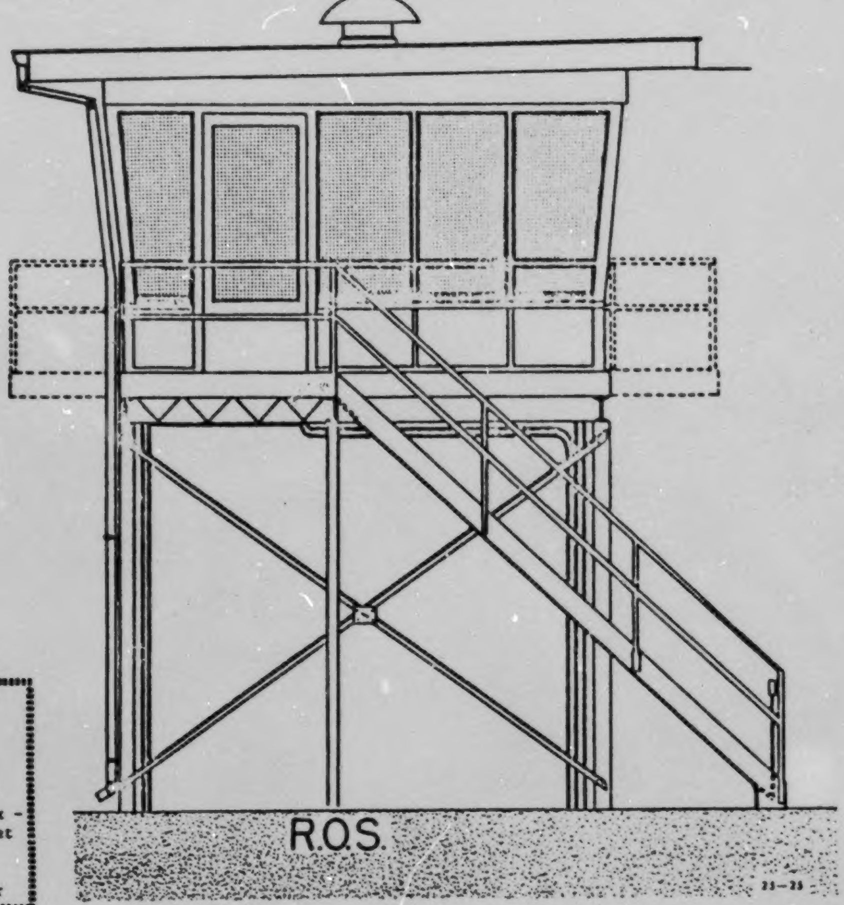
Foldout 5. Synopsis for classification of radar echoes.

REPRESENTATIVE OBSERVING SITE

TYPICAL EQUIPMENT LOCATION



1. AN/GMQ-10 Indicator Recorder, mounted on stand, 21" above platform.
2. AN/TMQ-11 Indicator
3. Bench (Top 30" above platform)
4. Intercom
5. Selector Switch
6. Microbarograph
7. Autographic Transcriber (Top flush with Bench)
8. AN/GMQ-11 Recorder
9. Aneroid Barometer
10. AN/GMQ-13 Indicator
11. Teletype
12. 4" Raised Platform
13. Chair
14. Communications Junction Box
15. Weather Equipment Junction Box - Columbia Type A Surface Cabinet 12" x 18" x 4"
16. Toilet Facilities
17. Bottle Type Elect Water Cooler



Foldout 6. Example of observing site.

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25251 01 25

WORKBOOK

Unit Operation, Equipment, and Special Topics

SELF-TEACHING AIDS
CRE
VRE
SRG

This workbook places the materials you need *where* you need them while you are studying. In it, you will find the Chapter Review Exercises and their answers, and the Volume Review Exercise. You can easily compare textual references with chapter exercise items without flipping pages back and forth in your text. You will not misplace any one of these essential study materials. You will have a single reference pamphlet in the proper sequence for learning.

These devices in your workbook are autoinstructional aids. They take the place of the teacher who would be directing your progress if you were in a classroom. The workbook puts these self-teachers into one booklet. If you will follow the study plan given in "Your Key to Career Development," which is in your course packet, you will be leading yourself by easily learned steps to mastery of your text.

If you have any questions which you cannot answer by referring to "Your Key to Career Development" or your course material, use ECI Form 17, Student Request for Assistance," identify yourself and your inquiry fully and send it to ECI.

Keep the rest of this workbook in your files. Do not return any other part of it to ECI.

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Air University

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Study Reference Guide

Chapter Review Exercises

Answers For Chapter Review Exercises

Volume Review Exercise

ECI Form No. 17

STUDY REFERENCE GUIDE

1. *Use this Guide as a Study Aid.* It emphasizes all important study areas of this volume.

2. *Use the Guide as you complete the Volume Review Exercise and for Review after Feedback on the Results.* After each item number on your VRE is a three digit number in parenthesis. That number corresponds to the Guide Number in this Study Reference Guide which shows you where the answer to that VRE item can be found in the text. When answering the items in your VRE, refer to the areas in the text indicated by these Guide Numbers. The VRE results will be sent to you on a postcard which will list the *actual VRE items you missed.* Go to your VRE booklet and locate the Guide Number for each item missed. List these Guide Numbers. Then go back to your textbook and carefully review the areas covered by these Guide Numbers. Review the entire VRE again before you take the closed-book Course Examination.

3. *Use the Guide for Follow-up after you complete the Course Examination.* The CE results will be sent to you on a postcard, which will indicate "Satisfactory" or "Unsatisfactory" completion. The card will list *Guide Numbers* relating to the questions missed. Locate these numbers in the Guide and draw a line under the Guide Number, topic, and reference. Review these areas to insure your mastery of the course.

Guide Number	*Guide Numbers 100 through 114*
100	Introduction; AWS Mission and Organization; Career Progression; pages 1–6
101	Training; Training Program, Determining Training Requirements, Administering the Training Program; pages 6–12
102	Training; General Military Training, Miscellaneous Training, Surface Observing Certification and Authentication of Nonweather Personnel (AWSR50–10); pages 12–16
103	Management and Supervision; pages 16–21
104	Introduction; Fundamentals of Meteorology; Pressure and Wind Circulation; pages 22–27
105	Fundamentals of Meteorology; Temperature and Moisture, Airmasses, Frontal Weather Effects; pages 27–34
106	Mathematics and Meteorological Tables; Interpolation; pages 34–36
107	Mathematics and Meteorological Tables; Table Preparation; pages 36–42
108	Introduction; Manipulating Surface Observing Equipment; Cloud Height Measuring Sets; pages 43–50
109	Manipulating Surface Observing Equipment; Visibility Measuring Equipment, Precipitation Gage, Pressure Instruments; pages 50–57
110	Manipulating Surface Observing Equipment; Temperature-Humidity Measuring Instruments, Wind Measuring Sets; pages 57–63
111	Storm Detection Radar; Radarscopes, Azimuth and Range (A R), Range and Height Indicator (RHI), Plan Position Indicator (PPI), Radar Terms; pages 63–68
112	Storm Detection Radar; Operating Controls, Radar Observing Techniques, Storm Echoes; pages 68–76
113	Observing Facilities, Logs, and Equipment; pages 76–83
114	Communications and Copying Equipment; pages 83–89

MODIFICATIONS

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CHAPTER 2

Section 5

Objectives: (1) To be able to explain the fundamentals of the general circulation, pressure patterns, and local winds; (2) to be able to describe the methods of heat transfer and the greenhouse effect; (3) to be able to explain the change of state processes; (4) to show ability to identify the airmass types and classifications; (5) to be able to describe how airmasses are modified; and (6) to identify the weather patterns and frontal effects associated with the cold, warm, and occluded frontal systems.

1. Why are the boundaries between layers of the atmosphere diffuse and difficult to identify? (5-1)

2. What is the relationship between air temperature and the ability of the air to support moisture? (5-2)

3. Why is water vapor of major importance in meteorology? (5-2)

4. What is the primary cause of all weather phenomena? (5-3)

5. What two reasons cause the general circulation to assume the theoretical "three-cell" pattern? (5-4)

6. In the Northern Hemisphere, where are the areas of high pressure found? (5-5)

7. What causes the variation of position and intensity of the semipermanent pressure systems? (5-7)

8. What are the names of the semipermanent high- and low-pressure systems of the Northern Hemisphere? (5-8)

9. What is the relationship between the upper level flow and the migratory pressure systems? (5-8, 9)

10. What causes the local winds to sometimes differ from the general circulation winds? (5-9)

11. What are the four categories of local winds? (5-10)

12. When radiational cooling occurs in the mountains, what type of wind occurs? What is its name? (5-10; Fig. 7)

13. What type of wind occurs when the air becomes lighter than the surrounding air and rises up the mountain slopes? (5-10; Fig. 8)

14. Explain the reason "sea breezes" occur in the afternoon hours along coastal areas? (5-11; Fig. 9)

15. Use each lettered sentence fragment to complete the partial statement below. Then write T or F, for true or false, after each part of the items.

A fall wind

a. is warm, dry, and gusty.

b. may attain velocities of 100 mph or more.

c. has little moisture.

d. flows down the mountain.

e. is colder, level for level, than the surrounding air as it descends.
(5-12)

16. Use each lettered sentence fragment to complete the partial statement below. Then write T or F, for true or false, after each part of the items.

A foehn wind

a. is warm, dry, and gusty.

b. is cold, dry, and gusty.

c. is moist and warm.

d. is found on leeward side of mountains.

e. is caused by the warming of air as it descends a mountain slope.
(5-13; Fig. 10)

17. What causes the increase in temperature when a "foehn" wind occurs? (5-13)

18. What is the name of the phenomenon or condition that occurs when there is strong flow perpendicular to a mountain range and the windspeed increases rapidly with altitude? (5-14)

19. What type of clouds are associated with the mountain wave? (5-15; Fig. 11)

20. Name the four basic methods of heat transfer. (5-18)

21. The earth receives what kind of radiation from the sun? The earth radiates what kind of radiation? (5-19)

22. The method of heat transfer that requires direct contact is called ________________ . (5-20)

23. What is the difference between the advection and convection method of heat transfer? (5-21)

24. Using the principles of the "greenhouse effect," mark the statements that are true or false.

a. Water vapor and clouds absorb a greater amount of long-wave radiation than short-wave radiation.

b. When the air is dry, the greenhouse effect is at a maximum.

c. The greenhouse effect causes a higher average surface temperature on cloudy nights.

(5-23)

25. How does the atmosphere receive its moisture? (5-24)

26. In the summer, as you near a large body of water, what would you expect the temperature to do? Why? (5-24)

27. What is the principle factor which determines the amount of evaporation that will take place? (5-25)

28. Saturation of the air can occur by the addition of ________________

or by ________________ it. (5-25)

29. The ________________ process accounts for the removal of most of the water vapor in the atmosphere. (5-26)

30. The change-of-state process by which a solid changes directly to a gas or a gas to a solid is called the ________________ process. (5-27)

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31. What type of clouds are usually formed by the process of sublimation? (5-27)

32. An airmass may be defined as a large body of air having about the same ________________________

________________________ and ________________________ properties. (5-29)

33. What three factors determine the properties of an airmass? (5-29)

34. What are the requirements of a good source region? (5-31)

35. How are airmasses labeled? (5-32)

36. What determines whether an airmass is classified as "w" or "k"? (5-32, 33)

37. If you were new at your weather station, what source of information would give you a fast reference as to the type of airmasses that affect your station? (5-36)

38. If an airmass moves from a Polar region out over a large body of water, what would be the probable airmass classification? Why? (5-32–38)

39. What determines the type and intensity of frontal weather? (5-42)

40. What differences in airmass properties and characteristics are used to locate and identify fronts? (5-44)

41. The discontinuity of wind across a front is primarily one of a change in ________________ (5-45)

42. When the warm air ahead of a cold front is moist and unstable, what type of clouds are associated with the front? (5-47; Fig. 12)

43. When the air behind the cold front is moist and stable, what type of weather occurs after frontal passage? (5-48; Fig. 12)

44. How does a warm front generally differ from a cold front? (5-50)

45. What is the general sequence of clouds with the approach of a warm front? (5-51; Fig. 13)

46. If the advancing cold front remains on the surface and forces the warm front and warm air aloft, what type of occlusion occurs? (5-53; Fig. 14)

47. If the cold front overtakes the warm front and the cool air behind the cold front slides up over the colder air ahead of the warm front, what type of occlusion occurs? (5-54; Fig. 15)

48. How do the weather patterns differ in the warm and cold front occlusions? (5-55; Figs. 14, 15)

Section 6

Objectives: (1) To be able to explain the use of mathematics in table construction; (2) to show ability to determine values from tables; and (3) to describe the preparation of meteorological tables.

1. Using table 3, determine the sea-level pressure when the corrected station pressure is 29.94 inches and the 12-hour mean temperature is 18° F. (6-2–6; Table 3)

2. Name two methods used to construct altimeter setting tables. (6-9)

3. When using the computer to determine an altimeter setting, what information is required? (6-9)

4. The first step, when using the computer to obtain an altimeter setting, is to obtain station pressure to the nearest ______________________ inch. (6-10)

5. When computing an altimeter setting by the *Manual of Barometry* method, what is the next step after finding the pressure altitude corresponding to your station pressure? (6-11)

6. Where would you find information concerning the extreme station pressure values for your station? (6-13)

7. What information do you need to know when you reduce station pressure to sea level using the *Pressure Reduction Computer?* (6-16)

8. What is the basic formula, in the *Manual of Barometry*, for determining sea-level pressure values? (6-18)

9. Using tables 5 and 6, a station pressure of 28.00 inches Hg, a station elevation of 600 meters, and a 12-hour mean temperature of 50° F., determine the sea-level pressure value. (6-18, 19; Tables 5, 6)

10. What trigonometric function determines angles that correspond to cloud height values? (6-21)

11. In a right triangle, what sides are used to determine the natural tangent value for angle A? (6-21, 22; Fig. 19)

12. Using Appendix B, a baseline of 400 feet and an observed cloud height of 450 feet determine the maximum angle that corresponds to the reportable height value of 400 feet. (6-25–28; App. B)

CHAPTER 3

Section 7

Objective: To be able to explain operating methods for obtaining proper measurement from surface observing equipment.

1. Ceilometers are operated when clouds exist within what range? (7-5)

2. During sweep adjustment of the RBC, if the sweep does not appear at 0°, what control is adjusted? (7-6)

3. What does the sync pulse indicate? (7-7)

4. What point of the RBC scope beam represents the base of the cloud? (7-9, *a*)

5. On the RBC, what is indicated by a wide trace at the bottom that tapers as it moves upward? (7-9, *d*)

6. What is the lower limit of cloud detection on the AN/TPQ–11 radar cloud detecting set? (7-10)

7. What AN/TPQ–11 control aids evaluation of multiple cloud layers? (7-14)

8. A wider range of power returns can be shown in __________ mode on the TPQ–11. (7-15)

9. Select the settings from each of the TPQ–11 controls below that would best record echo returns during light rain from nimbostratus. (7-18; Table 9)

Mode–LOG or LIN.

Normalization–OFF or 15,000.

Quantizer–YES or NO.

ISO-ECHO–ON or OFF.

10. In general, reliable cloud base measurement by the AN/TPQ–11 radar is confined to what kind of cloud base? (7-19)

11. When is AN/TPQ–11 cloud top measurement unreliable? (7-20)

12. True or false. The transmissometer can best supply a general visibility indication in all directions. (7-22; Fig. 20)

13. What is the purpose of the AN/FMN–1 computer light intensity detector? (7-25)

14. What is the purpose of the light-setting switch on the AN/FMN–1 computer? (7-25)

15. During HIGH mode operation of the transmissometer, a 60-percent value actually indicates

____________________ percent transmissivity. (7-27)

16. How many inches of liquid precipitation does the measuring tube of the rain gage represent? (7-30)

17. How closely should you read the rain gage measuring stick? (7-32)

18. How should you find the water equivalent of solid precipitation? (7-33)

19. A proper location for an aneroid barometer is one that minimizes what effects? (7-37)

20. To what accuracy should you read the aneroid barometer? (7-38)

21. What type of barometer is the barograph? (7-39)

22. Calibration error, capillarity, and imperfect vacuum are grouped as what type of barometer error? (7-44)

23. What is the purpose of the attached thermometer on the mercurial barometer? (7-45)

24. What does each graduation on the mercurial barometer vernier scale equal? (7-47)

25. What precaution is necessary when moistening the wet bulb during high temperature and low humidity? (7-55)

26. Give three precautions to observe while whirling the sling psychrometer? (7-60)

27. When reading the thermometer, what are two sources of inaccuracy to avoid? (7-61)

28. How excessive must be the error before the standby system replaces the TMQ–11? (7-63)

29. The wind indicator dial and recorder chart provides wind direction in relation to which north, magnetic or true? (7-65)

30. When is it mandatory to change the wind recorder chart? (7-66)

Sections 8, 9, and 10

Objectives: To be able to: (1) name the basic controls for operating the FPS–77 radar; (2) state how each control contributes to detection of storms and severe weather; (3) state the general criteria of good observing facilities and state essential rules affecting the locations of the various types of observing sites; (4) describe how to maintain records for equipment operating logs and communication outages; and (5) explain the purpose of duplication equipment.

1. What are some of the advantages of the FPS–77 over previous radar sets? (8-1)

2. What are the types of scopes used on the FPS–77 radar? (8-2)

3. When using the A/R scope, what does the height of the blip indicate? (8-3)

4. What type of presentation is displayed on the RHI scope? (8-4)

5. What type of presentation is displayed on the PPI scope? (8-5)

6. Can the remote scope of the FPS–77 radar work independently of the main PPI scope? (8-7)

7. Check your understanding of the principles related to inherent errors in radarscope interpretation by completing each of the following items.

a. The four technical terms used to describe possible errors in radarscope interpretation are

____________ , ____________ , ____________ , and ____________ ____________ .

b. Attenuation is a reduction of radar energy because of ________________ , ________________ , or ______________________________ .

c. Resolution is the ability of the radar set to ________________ between two targets.

d. The three types of target resolution are ________________ , ________________ , and ________________ .

e. The ability of a radar set to separate two closely spaced targets at the same range and elevation is ______________________________ resolution.

f. The ability of a radar set to differentiate between two targets at the same bearing but at different ranges is ________________________ resolution.

g. The ability of a radar set to differentiate between too closely spaced targets which are positioned at the same range and bearing is ______________________________ resolution.

h. The bending of the radar waves through the atmosphere is caused by density differences and is classified as ________________________ .

i. Under *abnormal* atmospheric conditions, the radar beam can be refracted or distorted so that it causes echoes to appear on radarscopes where no clouds exist. This is classified as ____ .

(8-8–14)

8. What is the main purpose of the IF ATTENUATOR on the FPS–77? (8-18)

9. What is the main advantage of the ISO ECHO alarm circuit on the FPS–77? (8-20)

10. What is the echo memory feature on the FPS–77? (8-22)

11. Classification of echoes for reporting purposes involves consideration of ________________________ , ________________________ , continuity of pattern, and meteorological processes. (8-24)

12. How does the appearance of convective echoes differ from stratiform echoes on the FPS–77 PPI scope? (8-25)

13. The FPS–77 radar provides quantitative measurements of signal intensity by using the ____________ ______________________________ feature. (8-26)

14. How can you accurately determine the range and width of an echo on the FPS–77? (8-31)

15. How is echo movement and speed determined on the FPS–77? (8-32)

16. A bright band normally occurs in the region of melting snow about 1000 feet __________________ the melting level (0° C). (8-35)

17. What does a squall line resemble on the PPI scope? (8-37)

18. What type of configuration does a tornado produce on the PPI scope? (8-39)

19. What is generally the first indication on radar of an approaching hurricane? (8-40)

20. What are two important operating precautions to remember when using the FPS–77 radar set? (8-43)

21. What criteria should be considered when selecting a suitable location for an observing site? (9-2)

22. After selecting a suitable location for a fixed observing site, what further criteria must be considered for the observing structure? (9-3–5)

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23. The preferred configuration for a surface observing structure is a ________________ building near the ________________________ of the primary instrumented runway. (9-7)

24. What is considered to be the location of the primary upper-air observing site? (9-10)

25. What criteria should be considered when selecting an upper-air observing site? (9-10–12)

26. When you use tactical observing equipment without shelter, what sources tell you where you can obtain necessary shelter? (9-13)

27. Observing support functions will generally be ______________________ with and use the ________________ ________________ as the function or unit they are supporting. (9-14)

28. Using figure 49, at what time and how often are barometer comparison readings taken for standardizing a new aneroid barometer? (9-16; Fig. 49)

29. Before posting a mean correction to a new aneroid barometer, what criteria must be met for entries in column 14B of AWS Form 85? (9-20; Fig. 49)

30. How long is AWS Form 85 kept on file? (9-21)

31. What is the purpose of AWS Form 42, Communications Outage Log? (9-22)

32. Preventive maintenance listed on –6 work cards shows the ____________ maintenance requirements and ________________ interval between performance of each routine. (9-26)

33. Give two symptoms indicating that the chart drive lever in the transmissometer might have been accidentally pushed to STOP. (9-30)

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34. Give one symptom indicating that the chart movement switch on the wind recorder might have been accidentally pushed off. (9-31)

35. How can you insure that the barograph chart cylinder is in place? (9-32)

36. Why must you replace the wet-bulb wick periodically? (9-33)

37. If you have a copper-brass rain gauge, what monthly maintenance is desirable? (9-34)

38. Why should weather observations be disseminated to users immediately? (10-1)

39. There are two major types of autographic transcriber systems used in the weather units. What are these systems and their advantages? (10-3–5)

40. What requirement is placed upon the use of voice communications in local dissemination and why is it necessary? (10-8)

41. What is your responsibility when the telephone is used as a backup method for disseminating weather observations? (10-9)

42. In addition to the autographic systems and the telephone being used for dissemination of observations, there are two other systems quite common overseas. What are these two other systems? (10-10, 11)

43. How does the forecaster primarily use the PFSV? (10-13)

44. As a weather observer in a detachment, what would your duties include for transmission and receipt of weather data via teletype? (10-15, 16)

45. Where is the ADCAD position normally located? (10-18)

46. Where is the OWS system normally located, and what is transmitted over this system? (10-20, 21)

47. What weather circuit utilizes the Model 311, Electronic Weather Data Printer? (10-22)

48. What is the principal purpose of the facsimile recorder? (10-23)

49. What precaution is necessary when utilizing the ozalid streamliner? (10-26)

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MODIFICATIONS

Pages 22 - 26 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

ANSWERS FOR CHAPTER REVIEW EXERCISES

CHAPTER 2

Section 5

1. Because of the unequal distribution of atmospheric pressure and temperature.

2. The relationship between temperature and the moisture content of the air is that warm air supports more moisture than cold air.

3. Because the presence of water vapor is necessary for cloud formation, and it acts as a regulator of the earth's temperature.

4. The primary cause of all weather phenomena is the unequal distribution of solar heat acting upon the earth and atmosphere.

5. The rotation of the earth and the deflection of moving particles to the right in the Northern Hemisphere establishes the "three-cell" pattern.

6. At the pole and 30° north.

7. The unequal heating of land and water masses cause a seasonal variation in position and intensity of the systems.

8. The Bermuda, Siberian, and Pacific Highs, and the Aleutian and Icelandic Lows.

9. The migratory pressure systems generally move along in accordance with the upper level flow pattern.

10. The rough land surfaces and the land and water temperature differences.

11. Local-cooling, local-heating, adjacent local-heating and cooling, and the forced circulations.

12. The local-cooling-type wind. The mountain breeze.

13. The local-heating-type wind called the valley breeze.

14. Sea breezes occur in the afternoon hours at coastal areas due to the increased temperature of the land which causes hot air to rise over it. Then the cooler air over the water flows landward to take its place.

15. *a.* F

    b. T

    c. T

    d. T

    e. T

16. *a.* T

    b. F

    c. F

    d. T

    e. T

17. The downslope motion of the air causes compression and subsequent heating of the air as it moves down the mountain slope.

18. The mountain wave.

19. Lenticular and roll clouds.

20. Radiation, conduction, advection, and convection.

21. Short-wave; long-wave.

22. Conduction.

23. Advection transfers heat in the horizontal, whereas convection is the transport of heat in the vertical.

24. *a.* T

    b. F

    c. T

25. By evaporation from lakes, rivers, and oceans.

26. The temperature should drop. Because heating is occurring, and evaporation of the water is cooling the air of the surrounding area.

27. The air temperature. That is, warm air can hold more moisture than cold air.

28. Water vapor; cooling.

29. Condensation.

30. Sublimation.

31. Cirrus clouds.

32. Horizontal temperature and moisture.

33. The physical and geographical nature of the underlying surface and the time it remains over this surface.

34. The requirements of a good source region are (1) that an area have a fairly uniform surface, (2) uniform temperatures, and (3) preferably an area of high pressure where the air has a tendency to stagnate.

35. According to source region. That is, "T" (tropical), "A" (artic), "P" (polar), and "E" (equatorial).

36. Whether the airmass is warmer (w) than the underlying surface or colder (k) than the underlying surface.

37. The Terminal Forecast Reference File.

38. mPku. Because as the airmass leaves the Polar source region and passes over water, it becomes moist (m). It came from a polar (P) region and is colder (k) than the underlying surface. The unstable (u) classification is because the airmass is receiving heat in its lower layers and is, therefore, said to be unstable.

39. Frontal weather is determined largely by the slope of the front, water vapor content and stability of the airmasses, and the speed of the front.

40. Temperature, water vapor content, wind, cloud types, and pressure changes.

41. Direction.

42. The clouds are predominantly cumuliform.

43. Low stratus clouds and fog persist for some time after frontal passage when the air behind the front is moist and stable.

44. A warm front differs from a cold front in that the associated weather pattern is more extensive with the warm front and precipitation is of a more continuous nature.

45. Cirrus, cirrostratus, altostratus, and nimbostratus.

46. A cold front occlusion.

47. A warm front occlusion.

48. The warm front occlusion has a wider zone of weather and extends farther in advance of the warm occlusion than with a cold front occlusion.

Section 6

1. ~~1041.8 mb~~. 1043.2mb

2. The *WBAN Manual of Barometry* method and the method used in conjunction with the *Pressure Reduction Computer.*

3. Station pressure and station elevation.

4. .005 inch.

5. Subtract, algebraically, the station elevation from the pressure altitude value.

6. In the station Climatic Data Summaries.

7. Station pressure to the nearest .005 inch, the 12-hour mean temperature, and the derived "v" value.

8. $P_o = P \times r$.

9. 1019.3 mb.

10. The tangent function of angle A.

11. The opposite side over the adjacent side.

12. 49°.

CHAPTER 3

Section 7

1. Within the height measuring capability of the set.

2. Sweep length control.

3. Sync pulse indicates whether the indicator sweep and the projector are synchronized or not.

4. The base of the cloud is at the widest part of the scope trace.

5. It indicates vertical visibility into surface-based obscuring phenomena.

6. 500 feet above the antenna.

7. RANGE NORMALIZATION.

8. LOG.

9. Mode–LOG.

   Normalization–15,000.

   Quantizer–YES.

   ISO-ECHO–ON.

10. The sharply defined base of a nonprecipitating cloud.

11. When intense precipitation (over 0.75) inch/hour is occurring.

12. False.

13. To differentiate between day and night illumination.

14. The switch allows selection of the light setting for which you want computer values.

15. 12.

16. Two inches.

17. To the nearest 0.01 of an inch.

18. Pour a measured amount of warm water into the rain gage (collector ring and measuring tube removed), measure the entire amount in the measuring tube, and then subtract the amount of warm water that you added.

19. Vibrations and variations of temperature.

20. To the nearest 0.005 inch.

21. A recording aneroid.

22. Instrument error.

23. To provide a basis for the temperature correction to the observed pressure.

24. Two one-thousandths of an inch.

25. Prevent the wick from drying out before the lowest reading is reached.

26. Whirl the psychrometer in the shade, free of obstructions, and away from your body while facing the wind.

27. Prevent your body heat from affecting the thermometer and avoid parallax error.

28. The error must exceed 1° F. in the dry bulb or 2° F. in dewpoint.

29. Magnetic north.

30. At 0000 LST on the first day of the month.

Sections 8, 9, and 10

1. The FPS–77 radar set is designed as a storm detection radar, operating at a longer wavelength than earlier radar sets. This allows the set to detect storm cells better and have less attenuation from precipitation.

2. There are three types of scopes used on the FPS–77 radar. They are (1) the PPI scope, (2) the RHI scope, and (3) the A/R scope.

3. The height of the blip on the A/R scope is an indication of echo intensity and actual range.

4. The RHI scope displays a vertical cross section of the echoes.

5. The PPI scope presents a maplike picture with the antenna at the center.

6. No. The remote PPI scope operates only when the console PPI scope operates.

7. *a.* attenuation, resolution, refraction, and anomalous propagation.

   b. reflection, absorption, or scattering.

   c. differentiate.

   d. bearing, elevation, and range.

   e. bearing.

   f. range.

   g. elevation.

   h. refraction.

   i. anomalous propagation.

8. The main purpose of the IF ATTENUATOR is to permit comparison of target echo intensities by the "gain reduction method."

9. The ISO ECHO alarm allows you to set a predetermined threshold level that, when reached, will cause the buzzer to sound. This alerts you to storm development without continuous radar monitoring.

10. It is a feature on the PPI scope that retains the target pattern until it is deliberately erased.

11. Configuration, coverage.

12. Convective echoes have sharp outlines and uneven texture, whereas stratiform echoes show uniform, sheetlike echoes with fuzzy borders.

13. ISO ECHO.

14. By using the RANGE STROBE on the A/R scope.

15. "Write" a new pattern on the PPI scope without erasing the previous pattern. This enables you to determine the necessary information for computing movement and speed of the echo pattern.

16. Below.

17. A squall line pattern resembles a cold front on the PPI scope.

18. A tornado normally is displayed as a figure "6" on the PPI scope.

19. A prehurricane squall line, located about 200 miles from the center is usually the first indication of the approaching storm.

20. You should insure that the PPI intensity control is set at a level that will not burn the face of the tube, and the magnetron will be operated at the correct current level.

21. When selecting a suitable location for the observing site, you should consider local climatology, observing structure, length of instrument cable runs, and communications requirements.

22. The structure should be constructed so as to provide adequate safety, working space, and basic human comforts. In addition, it must be suitably located on the airfield complex that affords an unobstructed view of both ends of the primary instrumented runway.

23. Separate, midpoint.

24. The primary upper-air observing site is considered to be at the location of the pressure measuring instrument used to calibrate the flight instruments.

25. A site should be selected that minimizes the probability of losing data due to fixed obstructions, such as buildings, trees, and towers.

26. A shelter may be obtained under TA 006 for tent-type shelters and TA 010 for vehicle-type shelters.

27. Located, same, structure.

28. Barometer comparison readings are taken twice daily at 6-hour intervals with reading at the same two times each day for standardizing a new aneroid barometer.

29. You must have 20 consecutive daily comparisons (not including the first 5 days' readings) in which no entry in column 14B has exceeded ±.010 or ±0.3 mb.

30. AWS Form 85 is kept on file until the aneroid barometer is replaced.

31. AWS Form 42 should be used for documenting communications outages. Time of initial notification of a deficiency and all followup calls should be recorded on AWS Form 42.

32. Minimum, maximum.

33. With power on, the chart does not move and the clock is not ticking.

34. The power is on because the recorder lights are on, but the chart reel fails to move.

35. Give the cylimder a gentle rotational twist to set the gears.

36. The wet wick attracts dirt that affects evaporation.

37. Monthly maintenance of the rain gage consists of keeping the overflow can, measuring tube and collector funnel clean and free from oxidation. This is done by cleaning them with copper cleaner and/or fine steel wool.

38. A completely accurate and representative observation is very perishable, and should be relayed as soon as possible.

39. The two most commonly used autographic systems are Electrowriter and Telautograph. With either system, the weather observations are received as they are written; therefore, no time lag is involved. Also, these systems provide a permanent record of the observation as it is written.

40. A readback procedure is a requirement placed upon voice communications in locally disseminating data to insure that the data is correctly received.

41. Ensure that the telephone is not "tied up" with unofficial calls.

42. Two additional systems quite common overseas for dissimination of observations are tape recording devices and pony circuits.

43. The forecaster uses the PFS to relay the latest observation and other weather data to aircraft.

44. The duties would include daily handling and transmission of weather data over weather teletype circuits, such as: transmitting surface observations, pilot reports, radar reports and terminal forecasts. Also, it will be necessary to correctly decode, edit, and post this weather data.

45. The ADCAD position is usually located in the ROS.

46. The OWS system is usually located in the communications room of the weather station, and all the meteorological data (other than the current weather observation) is transmitted on this system.

47. The Model 311 Electronic Weather Data Printer is utilized on Comet III.

48. The facsimile recorder is used to receive weather charts that are plotted at various weather centrals and transmitted via cable to weather stations to provide weather support for their areas of concern.

49. The ammonia used to process the reproduction is very toxic. Be sure to follow the operating instructions to avoid injury to yourself or someone else.

STOP– 1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER. 2. USE NUMBER 1 PENCIL.

25251 01 25

VOLUME REVIEW EXERCISE

Carefully read the following:

DO'S:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, take action to return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that numerical sequence on answer sheet alternates across from column to column.
3. Use only medium sharp #1 black lead pencil for marking answer sheet.
4. Circle the correct answer in this test booklet. After you are sure of your answers, transfer them to the answer sheet. If you *have* to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if at all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If *mandatorily* enrolled student, process questions or comments through your unit trainer or OJT supervisor.
   If *voluntarily* enrolled student, send questions or comments to ECI on ECI Form 17.

DON'TS:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than with a #1 black lead pencil.

NOTE: The 3-digit number in parenthesis immediately following each item number in this Volume Review Exercise represents a Guide Number in the Study Reference Guide which in turn indicates the area of the text where the answer to that item can be found. For proper use of these Guide Numbers in assisting you with your Volume Review Exercise, read carefully the instructions in the heading of the Study Reference Guide.

Note to Sudent. This Volume Review Exercise contains 79 four-option items and 1 three-option item.

Multiple Choice

Note: The first three items in this exercise are based on instructions that were included with your course materials. The correctness or incorrectness of your answers to these items will be reflected in your total score. There are no Study Reference Guide subject-area numbers for these first three items.

1. The form number of this VRE must match

   a. my course number.
   b. my course volume number.
   c. the number of the Shipping List.
   d. the form number on the answer sheet.

2. So that the electronic scanner can properly score my answer sheet, I must mark my answers with a

   a. pen with blue ink.
   b. pen with black ink.
   c. number 1 black lead pencil.
   d. ball-point or liquid-lead pen.

3. If I tape, staple or mutilate my answer sheet; or if I do not cleanly erase when I make changes on the sheet; or if I write over the numbers and symbols along the top margin of the sheet,

   a. I will receive a new answer sheet.
   b. my answer sheet will be hand-graded.
   c. I will be required to retake the VRE.
   d. my answer sheet will be unscored or scored incorrectly.

Chapter 1

4. (100) A primary mission of the AWS is

   a. issuing a 6-inch snow accumulation forecast for a nearby city.
   b. providing a local Army commander with weather forcasts for maneuvers.
   c. conducting seminars for the weather indoctrination of local Aero Club and CAP members.
   d. providing weather information upon request to the Department of the Interior.

5. (100) According to the text, which of the following is considered an environmental phenomena?

   a. Volcanic activity.
   b. Tornado activity.
   c. Earthquakes.
   d. Solar flares.

6. (100) Which of the following weather units provides direct support to a numbered Air Force headquarters?

   a. AWS.
   b. Wing.
   c. Squadron.
   d. Detachment.

7. (100) Successful operation of a weather detachment is primarily dependent upon the

   a. number of 7-level personnel assigned and the DETCO's experience.
   b. number of weather officers and weather technicians assigned.
   c. assigned mission and number of personnel assigned.
   d. technical competence and close cooperation of the assigned personnel.

8. (100) The difference between the weather specialty description of the weather observer and the weather observer technician is that the weather observer

   a. does not become involved on supply and administrative functions.
   b. observes and records weather elements.
   c. plots weather maps, charts, and diagrams.
   d. performs organizational maintenance on weather instruments and electronic weather equipment.

9. (100) Completion of a CDC is required for award of which of the following AFSC's?

   a. 25271, 30270, and 25291.
   b. 25251, 25271, and 25370.
   c. 25251 and 25390.
   d. 25330 and 25370.

10. (100) A weather equipment technician will normally be assigned to a detachment that has which type of equipment?

    a. Radar and rawinsonde.
    b. Cloud and wind measuring.
    c. Transmissometer and test.
    d. Temperature and humidity.

11. (100) For which of the following activities or operations does the weather equipment superintendent have supervisory responsibility?

    a. Upper air research activities.
    b. Airborne and ground weather maintenance activities.
    c. Reconnaissance dropsonde operations.
    d. Radar and rawinsonde equipment operation.

12. (101) What does the "dual-channel OJT concept" refer to?

    a. Proficiency and performance training.
    b. Performance and job specialty development.
    c. Career knowledge and job proficiency development.
    d. Job specialty and job proficiency development.

13. (101) The purpose of qualification training is to increase

    a. knowledge and skill in an AFSC, but will not result in awarding of a higher AFSC.
    b. knowledge in an AFSC, but will not result in awarding of a higher AFSC.
    c. skill, not knowledge, in an AFSC and will result in awarding of a higher AFSC.
    d. knowledge and skill in an AFSC and will result in awarding of a higher AFSC.

14. (101) In what training category, if any, is the weather observer AFS?

a. A–highly technical skill.	c. C–semitechnical skill.
b. B–technical skill.	d. None of the above.

15. (101) The person responsible for the overall supervision of the detachment's training program is the

a. DETCO.	c. section supervisor.
b. training officer.	d. OJT supervisor.

16. (101) Which of the following duties is most likely the responsibility of an OJT trainer?

a. Inform DETCO of training status.
b. Monitor requests for training classifications actions.
c. Initiate OJT status requests for airmen.
d. Conduct oral, written, or performance tests.

17. (101) Which of the following options is an STS skill level code which indicates that training is needed to a partially proficient performance level?

a. 3c.	c. 1b.
b. 2b.	d. 4b.

18. (102) The purpose of general military training (GMT) is to

a. improve the job proficiency of military members.
b. improve the discipline of military members.
c. insure that officers and airmen remain abreast of the latest technical developments.
d. insure that officers and airmen are able to perform effectively in their military capacity.

19. (102) The purpose of AWSR 50–5, Miscellaneous Training, is to

a. insure that officers are trained properly.
b. insure that airmen are trained properly.
c. list and consolidate training requirements not covered by OJT and GMT.
d. list and consolidate all training levied by the Air Force, MAC, and AWS.

20. (102) The purpose of training nonweather personnel in accordance with AWSR 50–10 is to

a. authenticate nonweather personnel to take limited surface observations.
b. teach AFCS personnel weather and its associated problems.
c. qualify, certify, and show GCA personnel the problems associated with weather observing.
d. test nonweather personnel on their knowledge of weather.

21. (103) The technique "inform observers in advance of changes" provides for which basic need of people?

a. Opportunity.	c. Belonging.
b. Security.	d. Recognition.

22. (103) Observing tasks are classified as "variable" or "fixed" when you are

a. determining workload distribution.	c. establishing detachment operating instructions.
b. determining leave schedules.	d. establishing standard procedures.

23. (103) Which of the following options is *not* an example of a unit effectiveness check by the chief observer?

   a. Conducting an observers' meeting.
   b. Watching an observer take an observation.
   c. Checking plotted stations on a weather map.
   d. Checking the wind recorder roll for time checks.

24. (103) What is the primary consideration, if any, for personnel utilization in a weather unit?

   a. Agreement with detachment policies.
   b. The weather unit mission.
   c. The popularity of each decision.
   d. None of the above selections.

25. (103) How will you benefit by being selected as shift chief?

   a. Your privileges are increased.
   b. It helps to gain experience as a supervisor.
   c. It insures you a better understanding of human relations.
   d. It enables you to stay proficient as an observer.

Chapter 2

26. (104) Refer to figure 6 of the text. The three-cell circulation establishes belts of surface winds which are prevailingly

   a. easterly in midlatitudes, westerly on the polar, and easterly in the tropical latitudes.
   b. easterly in midlatitudes and westerly in the tropical and polar latitudes.
   c. westerly in the midlatitudes and easterly in the tropical and polar latitudes.
   d. westerly in the midlatitudes and westerly in the tropical and polar latitudes.

27. (104) Which of the following is the classification for the mountain breeze?

   a. Local-cooling.
   b. Local-heating.
   c. Adjacent-heating.
   d. Adjacent-cooling.

28. (104) At what time of day does the valley breeze reach its maximum windspeed?

   a. Sunrise.
   b. Midnight.
   c. Sunset.
   d. Midafternoon.

29. (104) At what time of day does the sea breeze reach its maximum windspeed?

   a. Sunrise.
   b. Midnight.
   c. Sunset.
   d. Midafternoon.

30. (104) What time of day would the land breeze be at its strongest?

   a. Just before dawn.
   b. Just before midnight.
   c. Afternoon.
   d. Sunset.

31. (104) When the bora wind occurs over the lowlands in conjuction with counterclockwise circulation, there

    a. are clear skies and good visibilities.
    b. are scattered clouds and scattered showers.
    c. is considerable cloudiness and rain.
    d. is a noticeable decrease in cloudiness and precipitation.

32. (104) Which of the following is *not* a characteristic of a foehn wind?

    a. Warm, moist wind.
    b. Warm. dry, and gusty wind.
    c. Found on the leeward side of mountains.
    d. Warming of cold air as it descends the mountain slope.

33. (104) Lenticular clouds may form singularly or in layers

    a. on the windward side of the mountain.
    b. near the upper frontal surfaces.
    c. at heights usually above 20,000 feet.
    d. below the roll cloud.

34. (105) Which two of the following heat transfer processes are essentially alike except for direction of movement?

    a. Radiation and convection.
    b. Conduction and convection.
    c. Advection and convection.
    d. Advection and conduction.

35. (104) The heat transfer process which is most significant in the formation of clouds is

    a. conduction.
    b. convection.
    c. radiation.
    d. advection.

36. (105) The physical act of changing the state of water to a water vapor is called

    a. evaporation.
    b. condensation.
    c. saturation.
    d. sublimation.

37. (105) The process which accounts for most of the removal of water vapor from the atmosphere is called

    a. saturation.
    b. sublimation.
    c. condensation.
    d. evaporation.

38. (105) The process by which water vapor is changed to a liquid state is called

    a. evaporation.
    b. sublimation.
    c. condensation.
    d. crystallization.

39. (105) An airmass is a large body of air having

a. varying characteristics in a vertical plane.
b. varying characteristics in a horizontal plane.
c. about the same horizontal temperature and moisture properties.
d. about the same vertical temperature and moisture properties.

40. (105) If an airmass moves out of a polar source region in the winter to an ocean area, how is the airmass classified?

a. cPks.
b. cPwu.
c. mPws.
d. mPku.

41. (105) Which of the following options characterizes the weather associated with an airmass that is cooled from below?

a. Stratiform clouds and good visibility.
b. Cumuliform clouds and good visibility.
c. Cumuliform clouds and poor visibility.
d. Stratiform clouds and poor visibility.

42. (105) Refer to figure 12 of the text. No weather occurred prior to a frontal passage, and the weather accompanying the front extends approximately 100 miles behind the front. This front is best described as

a. a fast-moving cold front.
b. a slow-moving cold front.
c. an occluded front.
d. a stationary front.

43. (105) Refer to figure 13 of the text. The gradual thickening of cirrus clouds usually indicates the approach of

a. a cold front.
b. a warm front.
c. an instability line.
d. an occluded front.

44. (105) Which of the following statements describes the warm front occlusion?

a. The weather is found in the warm sector only.
b. The weather is found behind the occlusion.
c. The cold air behind the front is colder than the air ahead of the warm front.
d. The cold air ahead of the warm front is colder than the air behind the advancing cold front.

45. (105) The thunderstorms imbedded within the stratiform layer of the warm front occlusion usually occur

a. with the passage of the surface cold front.
b. with the passage of the surface warm front.
c. ahead of the surface warm front.
d. after passage of the surface warm front.

46. (106) Using table 3, interpolate to find the sea-level pressure for a mean temperature of 15° F. and a station pressure of 29.750 inches.

a. 1035.6 mbs.
b. 1036.0 mbs.
c. 1036.6 mbs.
d. 1038.0 mbs.

47. (107) When you are using the pressure reduction conputer to obtain an altimeter setting, what information is required?

    a. Station pressure and 12-hour mean temperature.
    b. Station pressure and station elevation.
    c. Sea-level pressure and 12-hour mean temperature.
    d. Sea-level pressure and station elevation.

48. (107) When computing altimeter setting values using the *Manual of Barometry* method, what is the first step that must be performed?

    a. Enter the table with the station pressure reading.
    b. Enter the table with the station elevation.
    c. Convert the station elevation to meters.
    d. Subtract station elevation from the pressure altitude value.

49. (107) Using Appendix A, determine the altimeter setting for a station of 1500 feet elevation with a station pressure of 27.70 inches.

    a. 29.25.
    b. 29.26.
    c. 29.15.
    d. 29.16.

50. (107) Using tables 5 and 6, determine the sea-level pressure when station pressure = 27.50 inches, 12-hour mean temperature = 50° F., and station elevation = 550 meters.

    a. 990.1 mbs.
    b. 995.1 mbs
    c. 1000.3 mbs.
    d. 1002.3 mbs.

51. (107) Which of the following trigonometric functions is used to determine angles of reportable heights in a right triangle?

    a. Sine.
    b. Cosine.
    c. Tamgent.
    d. Cotangent.

Chapter 3

52. (108) Noise signals portrayed on the ceilometer indicator can be recognized by their

    a. broad scope deflection.
    b. tapered appearance.
    c. appearance on measuring scans.
    d. random patterns.

53. (108) To minimize the attemuating effects of a strong, low-level echo return on the TPQ–11 scope, you should use the

    a. ISO-ECHO.
    b. RANGE NORMALIZATION to 15000 feet.
    c. LOG mode.
    d. QUANTIZER.

54. (108) A more detailed display of features within a cloud are attainable on the TPQ–11 recorder using

    a. LOG mode.
    b. LIN mode.
    c. IF ATTENUATION.
    d. NORMALIZATION.

55. (109) What automatic function does the light intensity detector of the RVR computer perform?

    a. Selects a day or night light setting.
    b. Selects the day or night computer function.
    c. Makes background computations.
    d. Processes received light for the computer.

56. (109) The overflow can of the rain gage

    a. holds the measuring tube in place.
    b. facilitates collection of solid precipitation.
    c. represents a measured amount of precipitation.
    d. measures solid precipitation.

57. (109) Before reading, the aneroid barometer should be

    a. manually corrected for temperature.
    b. adjusted for proper tolerance.
    c. routinely compared to a microbarograph.
    d. tapped lightly.

58. (109) When reading pressure instruments, you should read the

    a. aneroid barometer to the nearest 0.01 inch of mercury.
    b. microbarograph to the nearest 0.02 inch of mercury.
    c. aneroid barometer to the nearest 0.001 inch of mercury.
    d. microbarograph to the nearest 0.005 inch of mercury.

59. (109) Refer to figure 30,B, of the text. When a graduation on the vernier scale does not directly match a graduation on the fixed scale of the mercurial barometer, you should

    a. read the lowest valur of the two questionable graduations.
    b. read the highest value of the two questionable graduations.
    c. select a value halfway between the two graduations.
    d. reset the vernier scale until a reading is obtained where only one graduation lines up perfectly.

60. (110) To obtain a correct temperature reading from the psychrometer, you should

    a. induce freezing of the wet-bulb wick at wet-bulb temperatures 32° F. or below.
    b. ventilate the instrument 15 minutes before reading.
    c. sling the psychrometer near your body to protect the instrument from the wind.
    d. repeat readings until the wet-bulb temperature rises.

61. (110) If the dewpoint indicator reads higher than the temperature on the humidity-temperature set during periods of fog or precipitation, you should

    a. consider the dewpoint to be the same as the temperature.
    b. use the psychrometer at the ROS.
    c. consider the temperature to be the same as the higher value of the dewpoint.
    d. begin comparison readings for a 6-hour period.

62. (111) The RHI on the FPS–77 radar presents a vertical cross section of the echoes along any azimuth from the earth's surface to the height limit of

a. 50,000 feet.
b. 40,000 or 80,000 feet.
c. 100,000 feet.
d. 20,000 or 40,000 feet.

63. (111) The sweep ranges on the FPS–77 PPI scope are

a. 30, 60, 120, and 200.
b. 25, 50, 75, and 100.
c. 20, 40, 60, and 100.
d. 25, 75, 100, and 200.

64. (111) Anomalous propagation of the radar beam is most likely to occur when

a. abnormal atmospheric conditions exist.
b. light precipitation is occurring.
c. the radar set is improperly tuned.
d. the antenna is at higher elevation angles.

65. (112) Which control on the FPS–77 radar set prevents an echo target that is near the station from appearing stronger than an equally intense target that is farther away?

a. ISO-ECHO.
b. IF ATTENUATOR.
c. RANGE NORMALIZATION.
d. CFICON control.

66. (112) The main advantage of the ISO ECHO alarm circuit on the FPS–77 is that it

a. elevates the intensity of echoes.
b. warns you of a new echo.
c. alerts you to any further growth in the echo.
d. prevents damage to the PPI scope caused by strong echo returns.

67. (112) Echo intensity on the FPS–77 radar can be accurately determined at ranges up to

a. 120 nautical miles.
b. 140 statue miles.
c. 150 nautical miles.
d. 200 nautical miles.

68. (112) Which scope on the FPS–77 radar is best utilized to measure echo heights?

a. PPI.
b. A/R.
c. RHI.
d. Remote scope.

69. (112) At what height does the bright band normally occur?

a. In the region of melting snow about 1000 feet below the melting level (0° C.).
b. In the region of melting snow about 1000 feet above the melting level (0° C.).
c. In the region of freezing rain about 1000 feet above the melting level (0° C.).
d. Near the freezing level in mature thunderstorms, tornadoes, or hurricanes.

70. (113) Units which do not have an observing structure that meets the minimum ROS requirements may move into an operational control tower provided

a. there is 200 square feet available for the observer.
b. the necessary safety, field of view, and comfort for the observer are available.
c. the necessary instrument readouts would be available for the observer.
d. approval is obtained from the host installation commander.

71. (113) The solar observing functions making magnetometer, riometer, and ionospheric observations are normally situated in

a. existing structures.
b. specially designed facilities.
c. the forecasting function.

72. (113) Recording barometer comparisons on AWS Form 85 for routine comparisons is accomplished

a. daily.
b. weekly.
c. monthly.
d. as required by ASWM 105–8.

73 (113) AWS Form 42 is used to document

a. communications reports.
b. removal correction.
c. communications outages.
d. maintenance routines.

74. (113) Which of the following options is *not* your responsibility in reference to the care of psychrometers?

a. Placing new ivory black on worn etch marks.
b. Replacing warm wicks on the wet bulb.
c. Checking the aspirator assembly for frayed or loose connections.
d. Replacing the blower bearings of the aspirator.

75. (114) The main advantage of autographic transcribers is that

a. each receiving unit has a permanent record as the observation is written.
b. they improve the quality of your observation.
c. they disseminate your observation automatically.
d. this system eliminates transcribing errors and poor legibility.

76. (114) When the telephone is used as a backup method for disseminating weather observations, your responsibility is to

a. check each time that an observation is made to insure operational effectiveness.
b. insure that the telephone is not "tied up" with unofficial calls.
c. use standard FAA contractions.
d. keep the phone number a secret in the weather station.

77. (114) A pony circuit is normally used in an ROS to

a. transmit special observations only.
b. transmit the observation for worldwide distribution.
c. disseminate the observations to local users.
d. disseminate to AFCS command only.

78. (114) The purpose of the ADCAD system is to

a. disseminate weather to the control tower.
b. disseminate weather observations by longline in the United States.
c. improve observer-forecaster communications.
d. relay pilot reports.

79. (114) Observing and forecasting teams located at weather centrals prepare various charts and analyses that are necessary for weather station support. What type of equipment is used in the United States to receive these products?

    a. Ozalid reproducer.
    b. Thermofax reproducer.
    c. Facsimile and sattellite recorder.
    d. Zeroz recorder.

80. (114) There are various types of copying equipment utilized in weather units. When using one common type, extra precaution should be taken. What type is this and why the extra precaution?

    a. Thermofax, because of the bright light.
    b. Zeroz, because of the paper.
    c. Mimeograph, because of the blue ink process.
    d. Ozalid, because of the ammonia used in processing.

25251 02 7202

CDC 25251

WEATHER OBSERVER

(AFSC 25251)

Volume 2

Surface Weather Observations and Station Operations

15-1

Extension Course Institute
Air University

Preface

AS A WEATHER observer you are responsible for taking weather observations at Air Force bases and Army airfields and for disseminating these observations to using agencies. You need to be thoroughly familiar with the rules and techniques required to make an accurate, representative weather observation. This course, CDC 25251, *Weather Observer*, enlarges on the knowledge skills you have learned in the formal school. The CDC helps you to maintain satisfactory job performance and to progress in your career field.

This is Volume 2 of a four-volume course and consists of three chapters. The first chapter discusses the weather elements required for surface weather observations. It presents operational remarks and includes the supplementary data that is added (appended) to 3- and 6-hourly observations. The chapter deals with pressure and methods of pressure reduction to compute sea-level pressure. Chapter 2 provides guidance for encoding and disseminating weather observations and the processing of weather data. It also discusses the reporting and encoding procedures for RAREPs (radar reports). This discussion includes the criteria for taking radar observations and encoding them on AWS Form 104. Chapter 3 concludes the volume with a presentation of weather station duties, such as station administration and supply.

Five foldouts are printed and bound at the end of this volume to provide examples of each cloud type and to provide examples of surface weather observation entries on AWS Form 10 and weather radar observation entries on AWS Form 104.

If you have questions on the accuracy or currency of the subject matter of this text, or recommendations for its improvement, send them to Tech Tng Cen (TTOC), Chanute AFB IL 61868.

If you have questions on course enrollment or administration or on any of ECI's instructional aids (Your Key to Career Development, Study Reference Guide, Chapter Review Exercises, Volume Review Exercise, and Course Examination), consult your education officer, training officer, or NCO, as appropriate. If he can't answer your questions, send them to ECI, Gunter AFB, AL 36118, preferably on ECI Form 17, Student Request for Assistance.

This volume is valued at 36 hours (12 points).

Material in this volume is technically accurate, adequate, and current as of November 1971.

CHANGES FOR THE TEXT: VOLUME 2

Page	*Paragraph*	*Line(s)*	*Correction*
iii		Last	Change currency date to "April 1974."
1	1-2	9	Change "thunderstorn" to "thunderstorm."
7	1-46	7	Change "alocumulus" to "altocumulus."
13	1-84	9, 10, 11	Delete sentence beginning with "BI. . . ."
14	2-4	10	Change "at the below" to "at and below."
20	2-33	7 and 8	Change sentence beginning with "A variable. . . ." to "A variable ceiling is always reported when the ceiling is less than 3,000 feet and is optional at higher levels."
20	2-36		Delete.
20	2-37	1	Insert paragraph title "*Bases and tops of layers.*"
20	2-37	5	Delete "0918."
20	2-37	6, 7	Delete entire sentence.
21	2-40.*c*	1	Change "VINOVC" TO "BINOVC."
21	2-45	10, 11	Change "R" to "RW" and "RW" to "R."
22	Table 5		Change NOTE 2 to read: "When the prevailing visibility is estimated to be greater than the most distant marker, estimate the visibility to the nearest reportable value and enter it in column 4."
23	3-6	7, 8, 9	Delete.
23	3-7	15 thru 21	Delete.
28	4-9	3	Change "longer" to "larger."
29	4-23	8	Change "INTMTR-" to "INTMT R-."
29	4-26	4	Delete "- -" for very light intensity."
29	Table 7		Delete the "Very Light" information.
30	Tables 8, 9		Delete the "Very Light" information.
31	Table 10		Delete the "Very Light" information.
32	Table 11		At bottom of table, delete "and "- -" vor very light intensity."
34	4-46	3	Delete "beginning time."
34	4-46	5 thru 13	Delete.
34	4-47	2	Change "time of ending" to "and."
34	4-47	3	After the word "movement" delete remainder of paragraph.
35	4-49	3, 4	Change "MVG" to "MOVG."
35	4-50	4, 5	Delete "time of beginning."
35	4-50	7, 8	Delete.
35	4-50	10	Delete "B26."
35	4-50	13	Delete "PK WND 30/45 35."
35	4-52	2, 3	Delete "time of ending."

Page	*Paragraph*	*Line(s)*	*Correction*
35	4-52	5, 6	Change to read: "Record Observation: T + MOVD E."
35	4-52	7, 8	Change "TB3" to "TB03" and delete "PK WND 32/38 40."
35, 36	4-57		Delete.
36	Text table		Delete all text regarding "Showery precipitation" and "Wet snow" remarks.
39	5-21	4, 5, 6, 7	Delete entire sentence beginning with "It is a rare. . . ."
40	5-28	8 thru 12	Delete entire reference to "Barogram V" remark.
44	7-10	1, 2	Delete data enclosed in parentheses.
44	7-10, Col 2	4, 5, 6	Delete sentence beginning with "Follow each. . . ."
44	7-12		Delete.
44	7-13		Delete and replace with new paragraph: "7-13. If the wind speed is in excess of 25 knots since the last record observation, you will record a peak wind (PK WND) remark in column 13. Record PK WND, the direction and speed, and a slant followed by the time of occurance; e.g., PKWND 2743/23. Make this entry in the first record observation after its occurance if the peak speed has not been reported in a previous observation."
45	7-14	10	Change "once" to "twice."
45	8-2		Delete and replace with new paragraph: "8-2. To faciliate the locating of desired remarks in the transmitted message, the following order should be followed as closely as possible: • Runway visual range or runway visibility. • Surfaced-based obscuring phenomena. • Wind shifts. • RADAR reports of bases and tops. • Remarks elaborating on preceded coded data. • Three- and six-hourly additive data. • Radiosonde data. • Runway conditions. • Weather modification. *a.* Remarks that are considered operationally significent to aviation will have the identifier (ATC) immediately preceding these remarks. The identifier (MET) will be entered immediately preceding remarks that are considered significant to meteorologists."
46	8-10	8	Change "299 9915" to "299 99115."
49	8-37		Delete.
50	9-9	10	Change "once" to "twice."
50	9-10	12 thru 16	Delete.

Page	*Paragraph*	*Line(s)*	*Correction*
51	9-16	6, 7	Change sentence beginning with "The time. . . ." to read "The actual time refers to the time that you actually observed the last element for record, record special, and local observations."
51	9-16	8, 9	Delete sentence beginning with "The filing time. . . ." and replace with "Actual time for special observations is the time the element requiring the special is observed to occur."
51	9-17	9 thru 14	Delete remainder of paragraph beginning with "If the correction. . . ." and replace with the following: "If the correction is transmitted, enter (COR), in red, in column 13 followed by the GMT time that you make the transmission. Whenever you detect an error in a report already transmitted, disseminate a correction as soon as possible using the same dissemination given to the erroneous report. Suppose, though, you detect the error after later reports have superseded the erroneous data. If the later reports received the same or greater dissemination, no correction need be sent. Include in your corrected report all the data originally transmitted, though perhaps only one element was initially incorrect. To correlate the correction with the observation being corrected, refer to the standard time of the record observation if you transmitted it longline. Standard time is the hour to which a record observation applies such as 0900, 1600, etc. Use actual time for specials, locals, and locally disseminated record observations. Remember, discovering a mistake and *doing nothing about it* is a greater error than just making a mistake."
53	10-611		Change to read: "Radar reports of bases and tops."
53	10-6	16	Delete.
53	10-8	8	Insert "(MET)" before AC NE.
53	10-8	8	Change "FWR O 71" to "FWR O 10 71."
53	10-9	11	Insert "(ATC)" before T.
53	10-9	12	Delete "AB56."
53	10-9	13	Insert "(MET)" before PK WND and change "22/36 54" to "2236/54."
54	10-15	4	Insert "(ATC)" before CB.
54	10-15	5	Change to read: "W MOVG NE RWU SW (MET) TCU ALQDS."
54	10-15	6	Change "197/" to "1970."
54	10-18	13	Change to read: "Remarks, as appropriate."
54, 55	10-18	14 thru 21	Delete.
55	10-20,*a*(5)		Delete.
55	10-21,*f*		Delete.

Page	*Paragraph*	*Line(s)*	*Correction*
55	10-22	4, 5	Delete "each nationally published minima applicable to the runway in use." and replace with "2,400 feet and 6,000 feet."
55	10-24,*a*(4)		Delete "(other than very light)."
55	10-24,*b*	5	Change "26 knots" to "25 knots."
55	10-24,*c*	2, 3	Delete.
56	10-28		At end of paragraph add subparagraphs *e* and *f*: "*e*. Taken for ceiling and visibility values established locally because of their significance to aircraft operations. "*f*. Taken by Basic Weather Watch (BWW) stations at intervals not be exceed 20 minutes since the last observation during the following weather conditions: • Ceilings 1500 feet or less. • Visibility 3 miles or less. • Any form of precipitation. • Fog. Though a local is taken for the above, do not record or disseminate unless the ceiling and/or visibility changes by a reportable value since the last disseminated observations."
57	10-34	18,19	Delete remainder of sentence beginning with "except visibility. . . ."
60	10-60	6, 7	Change "are required" to "have the option."
60	10-60	11	Add new sentence "AWS Form 30, Pilot To Forecaster Service (PFSV) Log, is used for recording PIREPs if AWS Form 12 is not used."
60	10-61	8	Change "ALWDS" to "ALQDS."
61	11-2	7	Change "Airgound" to "Airground."
61	11-4		Delete entire "DISSEMINATION PROCEDURES" and replace with the following:

DISSEMINATION PROCEDURES

1. Space all entries on the T A evenly and write large enough to make for easy reading (use block letters).
2. Six mandatory requirements for each transmission, except for testing are:
   a. Identity of station (RAN).
   b. Identity of transmission by type (R, RS, S, L, PIREP, etc.).
   c. Actual time (GMT) of the observation.
   d. Message content. Form 10 entries: columns 1 through 13 except SLP; omit 3- & 6-hourly additive data.
   e. Time that transmission is completed in minutes past the hour.
   f. Initials of person making transmission (CB).

3. Use the following in placing data on the transcriber.
   a. Clear sky—use CLEAR.
   b. Wind.
      (1) Calm—use CALM.
      (2) Direction, magnetic only to nearest 10 degrees in 2 digits.
      (3) Speed, in 2 digits.
      (4) Example: 0309.

Page	*Paragraph*	*Line(s)*	*Correction*
			c. Altimeter, in 4 digits and flag all altimeter settings with ALSTG—ALSTG 3002. *d.* The contraction "ACFT MISHAP" is *never* disseminated over the transcriber. 4. Example: RAN R 1456 CLEAR 15 92/66 0309 ALSTG 3002 58/CB
62	11-5,*g*	11	Change "ABSCURED" to "OBSCURED."
63	11-14	8	Change "AFSR" to "AFCSR."
63	11-15		Delete and replace with new paragraph 11-15:

"11-15. The 28 ASR teletypewriter is used to transmit the special category collections on Comet IIA. Presently the following are the types of traffice that have been classified as special category:

Type	*Definition*
AIREP	A report from Air Force aircraft in MAC abbreviated AIREP code form or civil aircraft in ICAO form.
COMBAR	Aircraft report in COMBAR code form.
FOCST	A 4-hour terminal recovery forecast.
METAR	Surface weather report in METAR code.
PILOT	Winds aloft report in PILOT code.
PIREP	Pilot report in PIREP code.
PLATF	Plain language terminal forecast.
RAREP	Radar report.
RECCO	Weather reconnaissance observation.
ROCOB	Rocketsonde observation.
SIGWX	Supplemental reports of significant weather.
SPECI	Special weather reports in METAR code.
SYNOP	Synoptic weather reports.
TAF	Terminal forecast in TAF code.
TEMP	Upper level pressure, temperature, humidity, wind reports."

Page	*Paragraph*	*Line(s)*	*Correction*
63	11-16	5, 6	Delete remainder of sentence beginning with "local American telephone, etc." Insert "communications workload section or follow local procedures."
63	11-17		Delete paragraph and replace with new paragraph 11-17:

"11-17. TYPNO/TYPOK requests (circuit outage) within the Automatic Response to Query (ARQ) program will automatically retransmit for the inclusive outage time all precedence one and two messages, and NOTAMS, where required. When an extensive outage occurs, NOTAMS will be only rerun back to and including the last NOTAM summary issued. If following an outage, you do not require the aforementioned data, you will prepare a TYPNO/TYPOK report and transmit this information."

Page	*Paragraph*	*Line(s)*	*Correction*
66	12-6	7, 8	Delete "weather warning (WO) message" and insert "SVR message."
67	12-15, 16		Delete and replace with new paragraphs:

"12-15. **Classification of Radar Echoes.** Weather echoes as seen on a radarscope are reported by describing the type and intensity of associated

Page	Paragraph	Line(s)	Correction
			precipitation the intensity trend, and the horizontal and vertical size of echoes. Because radar reports are prepared, encoded, decoded, and plotted manually, and because they require considerable teletype transmission time and are perishable, they must be as concise as possible while still accurately describing the radar echoes. Echoes that are related geographically and by precipitation type and physical cause are grouped together for reporting, with the emphasis placed on grouping similar types of echoes rather than simply grouping together all echoes associated geographically. Elements of the radar report are indicated on the radar recording form. This form lists the elements in the order (sequence) that you encode them in RAREP code; therefore, the discussion of the elements also reveals the code form. The first element of a radar report, echo character, describes the general shape or form of the echo(es). "12-16. *Echo character.* As we mentioned in Section 8 of Volume 1, echoes are primarily described as cells, lines, or areas. Table 17 lists the descriptive terms that may be reported. Weather echoes associated geographically, by physical causes, and by precipitation type will be grouped together for reporting purposes according to the definitions in table 17."
67	12-17	6	Change "20" to "30."
67	12-21	10	Change "0238" to "0815" and change "0337" to "0837."
68	Table 17		Replace with new table 17 (attached).
70	Table 19		Replace with new table 19 (attached).
70	12-27	13	Add "NC" as contraction for "No change."
73	12-45	7	Change "100" to "125."
73	12-46	11	Change "MAX TOP" to "MT."
75	12-58		Delete and replace with new paragraph: "12-58. The 0637 observation on foldout 5 is used to illustrate the spacing and separation of the elements in RAREP format: PDQ AREA 7RW- +42/47 153/65 242/187 320/154 2715 MT 240 AT 170/25 CELLS AVG D6 LN10RW +315/123 243/155 12W 2820 MT 350 AT 275/112 LN NWRN END MOVMT 2718 SWRN END MOVMT 2823 You can see in this coded radar observation that spaces are used between elements that might be confused with other data."
75	12-60		Delete and replace with new paragraph: "12-60. Unlike scheduled hourly observations, special observations will be encoded to include only

Page	*Paragraph*	*Line(s)*	*Correction*
			the echoes of special interest. The selected echoes should be reported in complete detail including remarks. Special observations will be encoded and transmitted in intermediate collectives. Identify special observations and regular observations meeting the criteria for special observations by writing the contraction "SPL" in the left margin of the radar recording form, and transmitting this contraction after the time group."
75	12-62	14, 16, 18	Change "0338Z," "1623Z," and "1403Z" to "0338," "1623," and "1403."

LIST OF CHANGES

COURSE NO. 25251	CAREER FIELDS, POLICIES, PROCEDURES AND EQUIPMENT CHANGE. ALSO ERRORS OCCASIONALLY GET INTO PRINT. THE FOLLOWING ITEMS UPDATE AND CORRECT YOUR COURSE MATERIALS. PLEASE MAKE THE INDICATED CHANGES.
EFFECTIVE DATE OF SHIPPING LIST 4 Aug 75	

1. CHANGES FOR THE TEXT: VOLUME 2

a. Page 44, para 7-11, line 16: Change "attach" to "Prefix" and change "following" to "before."

b. Page 44, para 7-13: Delete and replace with the following:

7-13. If the wind speed exceeds 30 knots since the last record observation and this speed was not included in the body of a special observation transmitted on longline teletype, you will record a peak wind (PK WND) remark in column 13. Record PK WND, the direction and highest speed, a "/" and the time of first occurrence in the next record observation following its occurrence; e. g. PK WND 2731/23. Omit the remark if the speed is included in the body of this record observation.

c. Foldout 4, Rs 1256, col 13: Change "PK WND" from "PK WND 22/36 54" to "2236/54."

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Chapter

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Surface Weather Observations

YOUR WEATHER observation is the heart of the worldwide mission of the Air Weather Service. The duty forecaster depends on it. Weather detachments depend on it. Other weather agencies depend on it. Last, but most important, the pilot depends on it! Your potential ability to provide these people with representative and timely weather observations is one of the reasons you were selected for entry into the weather career field. Your aptitude scores, which must be among the highest in the Air Force, indicate that you have the ability to perform the complex duties of an observer. You must be able to think effectively and quickly to interpret weather instruments accurately and evaluate sky conditions and visibility. In many cases, your interpretations and evaluations determine whether an aircraft can land or whether the pilot must seek an alternate airfield. Staying abreast of the latest weather conditions is the part of your job that is difficult to measure by aptitude tests. It involves personal traits such as desire and *esprit de corps*. These traits are as essential to your work as the reference manuals and measuring instruments in your station. Eventually, your weather observation will combine the facts provided by your instruments with personal judgment. The judgment and desire you put into your work ultimately makes you different from all other observers. They become part of your personal standards.

2. In addition to knowing how to take an observation, you must know the operating procedures that are used for the various types of meteorological instruments and equipment. This involves knowing how to interpret the readings and scope presentations. Your reasoning ability is often tested when the weather conditions vary. Which item of equipment is more reliable? What happens when instrument readings differ from your own evaluations of the sky? These and many other problems are discussed throughout this volume.

3. This chapter provides the guidance necessary for you to take a complete observation. This discussion contains the presently accepted procedures for making entries on AWS Form 10. Chapter 1 also includes definitions of meteorological elements, criteria for making entries, coding instructions, order of entry, and general rules. The first discussion, state-of-the-sky evaluations, establishes a foundation for many AWS Form 10 entries.

1. State of the Sky

1-1. Have you ever looked at the clouds above and remarked, "It looks like rain?" Clouds have been called the signposts of weather. Their size, shape, and height give clues to the type of weather you can expect. Few people would mistake the weather signs of the dark, ominous "thunderhead" cloud from those of the white "cotton-puff" cloud floating innocently across a summer sky. However, except to the trained eye, the story told by clouds often goes unnoticed.

1-2. Clouds occurring in sequence describe a weather event much as chapters of a book unfold a story. For instance, the changes from cirrus to cirrostratus to altostratus clouds warn of an approaching warm front. Those small, puffy clouds that appeared harmless in the morning hours, but now have grown vertically into towering masses, speak silently of airmass instability—perhaps a thunderstorm during the night.

1-3. These cloud messages are not hard to understand, but they are not obvious. Clues to the approaching weather provided by the clouds are wasted if you cannot read them. To become a good cloud reader takes study and experience. To understand clouds we should consider their formation and classification.

1-4. Experienced meteorologists categorize all clouds into 10 basic forms. These basic forms are:

- Cumulus
- Cumulonimbus
- Stratocumulus
- Stratus
- Altostratus
- Nimbostratus
- Altocumulus
- Cirrus
- Cirrostratus
- Cirrocumulus

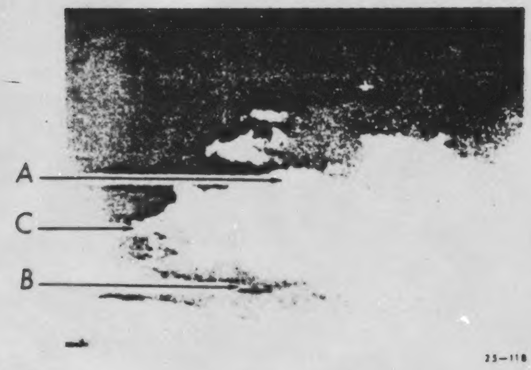

Figure 1. Cumulus.

Each basic form may be further classed into subtypes.

1-5. The subtypes are recognized internationally as 27 states of the sky—arranged as low, middle, and high clouds. Each state of sky possesses a distinguishing feature to separate it from the others. This feature may be the appearance, extent, size, or method of formation. The distinguishing features provide the clues that preview approaching weather. The first basic cloud form discussed, cumulus, is easily identified.

1-6. **Cumulus.** In the year 1803, an English pharmacist, Luke Howard, divided all clouds into three basic groups—cumulus, stratus, and cirrus. Cumulus, translated from Latin, means "heap." Heap aptly describes this cloud in most of its stages. In the earliest stage of development, cumulus usually forms in, and indicates, good weather. Figure 1,A, illustrates that it has clearly defined outlines during the building stage and appears very white in color. The base of the cumulus, figure 1,B, becomes darker as the cloud builds in size, but generally remains horizontal. After the building stage has gone on for awhile or ended, the edges of cumulus become ragged, being fragmented by the wind as shown in figure 1,C.

1-7. Notice the bulging appearance at A in figure 1. This is characteristic of building cumulus. Whatever its stage of development, cumulus always has the "cottony" appearance. Since these clouds form by convective action, the height of their base above the earth's surface is related directly to the amount of moisture at the surface. The higher the moisture, the lower in height above the surface are the bases. Although the water droplets in cumulus are very numerous, they are also very small in the cloud's early stages. As the cloud grows in size, large drops within the cloud increase in number. The large drops may be precipitated from the cloud or may continue to be carried within the cloud by vertical air motions.

1-8. Precipitation in the form of showers occurs with cumulus clouds of moderate development. Though this precipitation may be of moderate intensity, its duration is usually short-lived. These clouds do not produce the heavy rain and high winds that are associated with their bigger brothers, the cumulonimbus. Occasionally, the precipitation (showers) from cumulus clouds evaporates before it reaches the ground. This situation is referred to as *virga* and is characterized by a dark area immediately below the nearly uniform base of the cumulus cloud. This darkness, caused by precipitation, decreases in intensity as it descends beneath the cloud until it disappears (complete evaporation). When virga consisting of snow or ice crystals occurs, the virga portion is not as dark, and it appears more wispy. This is caused by the greater influence that wind has on falling snow and appears as a greater bending of the precipitation trails (virga). In any case, the precipitation does not reach the surface. AWS classes two subtypes of cumulus for coding.

1-9. *C_L–1 (cumulus).* Cumulus clouds encoded as low cloud "1" have *little vertical extent* and may appear *flattened.* Associated with good weather conditions (no precipitation), it is encoded as low cloud "1." This cloud is shown in foldout 1 as L1, cumulus humilis. When this cloud occurs below cumulonimbus or nimbostratus during precipitation, it is coded as L7. Under these conditions it usually appears ragged, changes shape rapidly, and is called cumulus fractus. Thus, the difference in classification of L1 and L7 is precipitation. When the convective forces that form cumulus continue their action, L1 cumulus grows into L2 cumulus.

1-10. *C_L–2 (cumulus).* Low cloud "2" is a cumulus cloud of *moderate* or *strong* (towering) vertical development. Generally, C_L–2 is accompanied by other cumulus or stratocumulus clouds that have their *bases at the same level.* When this cloud type develops a tower appearance, illustrated in the first L2 picture of foldout 1, you should remark this in your observation as TCU W. Towering cumulus may be distinguished from cumulonimbus by a lack of massiveness—i.e., its strong vertical growth is not matched by a horizontal spreading or bulging. Other important things to remember about this type are that it *does not* have a cirriform top, and it is rarely capable of producing thunder. Cumulus clouds of moderate or great vertical extent may, however, produce precipitation in the form of showers. When a cumulus develops both height and massiveness, it enters the next basic cloud category, cumulonimbus.

1-11. **Cumulonimbus.** Energy forces within a cumulonimbus, or CB, are capable of producing the most intense storm known in weather—the tornado. However, when cumulonimbus clouds are observed on the horizon they appear strikingly beautiful. Their tall, rounded masses reach gracefully skyward, often penetrating above cirrus cloud formations. Overhead, they present a more menacing picture. It is not uncommon for these clouds to produce heavy rain; lightning; strong, gusty surface winds; hail; and occasionally tornadoes.

1-12. To classify cumulonimbus clouds into the basic cloud forms, you should know that CB clouds are distinguished from cumulus clouds by the following characteristics:

- Massive appearance.
- Extensive vertical development.
- Fibrous or anvil top.
- Thunder and lightning.

1-13. Though the anvil feature of cumulonimbus is an identifying feature, sometimes only a fibrous appearance or a lack of sharp top outline is observed. When the cloud enters the dissipation stage, this upper section invariably assumes the classic anvil formation. Figure 2 shows several interesting features. At A, figure 2, the anvil top is visible. Points B and C show the fibrous appearance of a CB top. At B, the cloud is just beginning to lose its sharp outline. At C, the fibrous appearance is evident. Callout D points to a cell of convective activity that shows the typical sharp outlines of a building cumulus. Often you will encounter a dissipating cell next to a building one. The cloud shown with the anvil top, figure 2,A, is in the dissipating stage, as evidenced by the anvil. During dissipation, much of the cell's energy is directed downward. Consequently, surface weather may be even more severe during this stage.

1-14. The question often discussed among observers is when does the cumulus (moderate development) become cumulonimbus. There are several points of identification. When viewed from a distance, the massiveness and the appearance of the cloud top, already mentioned, offer positive means of CB identification. Overhead, other identifying guides are needed.

1-15. Thunder, lightning, or hail may be the sole indication of their presence. When you can't hear thunder overhead and are having trouble in deciding between nimbostratus or cumulonimbus, use the character (showery versus continuous) of the rain as a guide. A cumulonimbus cloud with extensive vertical development which has begun dissipating is generally preceded by an onrush of cool air a few minutes before the storm cell reaches overhead. The dark lower portion of a CB is usually accompanied by rapid-moving stratus fractus and cumulus fractus. Usually one of these signs can identify a CB from a cumulus.

1-16. A common occurrence with cumulonimbus cloud varieties is mammatus development. This feature may occur at the base of the cloud in the form of clearly defined bulges (pouches, fig.

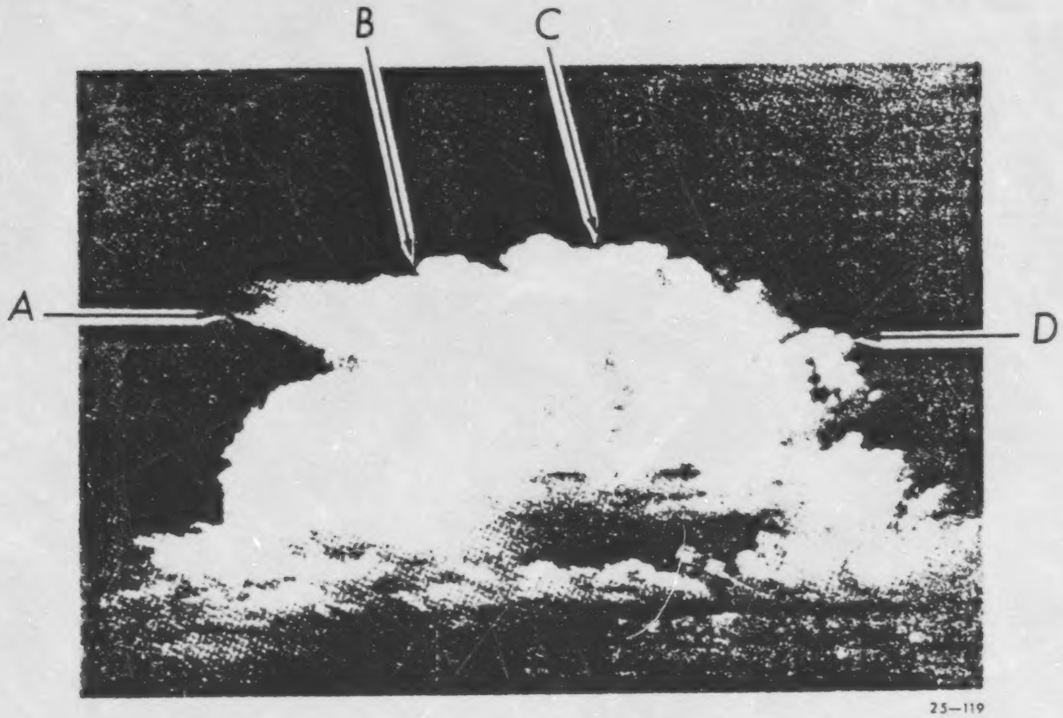

Figure 2. Cumulonimbus.

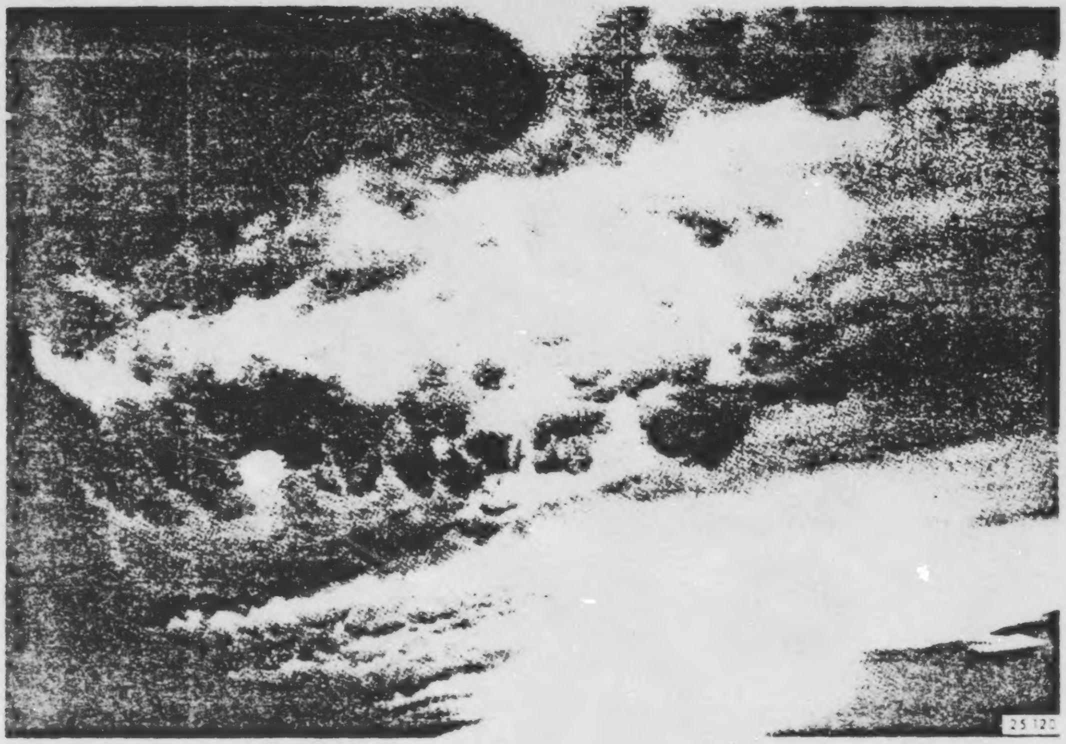

Figure 3. Mammatus.

3) or may appear at some level above the cloud base. In either case, these mammatus formations provide the forecaster with a good indication of the degree of instability present in the area. Though these cloud types may not have the development to produce tornadic activity, they can be used by the forecaster as indicators of potentially severe weather.

1-17. Studies of tornado development reveal that the base of the cumulonimbus cloud usually appears to be very dark and ragged before tornado activity occurs. The first sign of a funnel cloud often appears in the form of a *tuba* (a small appendage, often cone-shaped) beneath the cloud. When tubas are sighted with a CB, they frequently appear and withdraw from several portions of the cloud. A tuba that continues to develop toward the ground is referred to as a *funnel cloud* until it *reaches* the ground—then it becomes a *tornado*. The passage of a CB can cause a variety of changes in weather. Observing and disseminating these conditions present a challenge. For coding purposes, two subtypes of CB exist.

1-18. *C_L–3 (cumulonimbus).* Low cloud type "3" is cumulonimbus in its earliest stage of development. A low "3" cloud differs from other CB clouds because the summit lacks cirriform development (no anvil). Cumulonimbus clouds classified as L3 have summits which lack clear outlines but are neither clearly fibrous (cirriform) nor in the form of an anvil. Foldout 1, L3, shows an example of a cumulonimbus cloud without appreciable cirriform development. When you observe this type of cloud, add a remark to your observation to indicate the location (direction) of the cumulonimbus cloud from the station and the direction toward which it is moving.

1-19. The following are examples of cumulonimbus (CB) remarks entered in column 13 of AWS Form 10:

a. CB W MOVG E.
b. CB N–E MOVG SE.
c. CB NW. (This indicates that the direction of movement is unknown.)
d. CB 5NE MOVG E. (Enter distance (5) from station if it is known.)

These typical remarks for CB clouds are entered when no thunderstorm is being reported.

1-20. *C_L–9 (cumulonimbus).* Low cloud type "9" is distinguished from L3 by the presence of the *cirriform anvil.* If you find it difficult to determine whether the type is L3 or L9, the occurrence of lightning, thunder, or hail customarily belongs to the L9 CB. An L9 cloud requires a remark in column 13 of Form 10 that is similar to that for L3 clouds. When mammatus development is present, use the same remark format in column 13, *except* that the abbreviation "CBMAM" is used instead of "CB"; for example, CBMAM W MOVG E.

1-21. **Stratocumulus.** Stratocumulus ("strato-CU") clouds form in several ways. They are formed when stratus clouds near the earth's surface lift, cumulus clouds dissipate, or middle cloud layers lower. Stratocumulus are distinguished from cumulus clouds by their flatter appearance. As stratocumulus clouds merge into one layer, they appear grey with dark areas. These dark areas are the thicker portions of the strato-CU clouds. Stratocumulus is sometimes mistaken for altocumulus.

1-22. The best way to judge whether a cloud is stratocumulus or altocumulus is by the size of the individual elements. The *International Cloud Atlas* states that when the regularly arranged small elements of the cloud layer have an apparent width of more than 5°, the cloud is identified as stratocumulus. An easy method of determining this width is to hold three fingers at arm's length and see if the cloud element is larger than the three extended fingers. If it is not, then perhaps the cloud is altocumulus.

1-23. Foldout 1, L4 and L5, shows two examples of typical strato-CU clouds. The rounded masses and rolls of L5 are a unique feature of strato-CU. The variety of strato-CU shown at L4 is frequently formed by the spreading out of cumulus in the late afternoon when the surface heating is greatly diminished.

1-24. Precipitation rarely occurs in association with strato-CU clouds. When it does occur, it is usually weak and tends to be showery in character. Light snow showers are probably one of the most common forms of precipitation from strato-CU. During cold weather, strato-CU clouds frequently produce ice crystal *virga.*

1-25. *C_L–4 (stratocumulus).* Low cloud type "4" is encoded *only* when stratocumulus clouds are formed from the spreading out of cumulus or cumulonimbus clouds. During this spreading process, cumulus clouds may still be present. Foldout 1, L4, shows an example of stratocumulus clouds formed from the spreading out of cumulus clouds. When stratocumulus clouds form by other means, they are classified as low cloud "5." C_L–5 essentially includes all stratocumulus clouds *not* formed from the spreading out of cumulus clouds. If you cannot determine that stratocumulus formed from cumulus, code the cloud as L5.

1-26. *C_L–8 (cumulus and stratocumulus).* This state of sky is actually a combination of two other low cloud types—cumulus and stratocumulus. When cumulus and strato-CU clouds have *bases at different levels* and the strato-CU is formed by means *other than the spreading out of cumulus,* you classify the cloud type as L8. Often, a layer of stratocumulus is mistaken for stratus. Avoid that mistake with the following guideline.

1-27. **Stratus.** You can discriminate between stratus and a layer of stratocumulus by the uniform appearance of the stratus cloud base. Strato-CU always has an unequal distribution of darkness. When dissipating, stratus clouds may appear as large, irregular, dark patches between lighter colored portions already thinning. The entire cloud takes on a mottled or blotched appearance.

1-28. A stratus cloud usually forms very close to the earth's surface and is called *fog* when it is in contact with the earth (50 feet or less). It may also form under other cloud layers such as altostratus and nimbostratus. Stratus is capable of producing only light continuous precipitation, such as drizzle, ice prisms, or snow grains.

1-29. Stratus clouds are frequently confused with nimbostratus and altostratus. To help clarify identification, study this comparison:

Stratus:

- Produces only light precipitation, if any.
- May reveal the sun through its thinnest parts.
- Has a more uniform base than nimbostratus.
- Is generally grey.

Nimbostratus:

- Always produces heavier precipitation.
- Never reveals the sun.
- Has an uneven base.
- Is usually darker in appearance than stratus.

1-30. When the outline of the sun is distinguishable through stratus clouds, it can be used to distinguish between stratus and altostratus. The sun seen through stratus has a sharp, well-defined outline. Altostratus blurs the outline of the sun as if viewed through ground glass. When you are evaluating stratus cloud types, you must consider your past observations of the clouds as a basis for proper cloud identification. Stratiform clouds do not just suddenly develop. They usually are associated with a stable condition in the atmosphere and, therefore, evolve slowly.

1-31. *C_L–6 (stratus).* Low cloud "6" is a stratus cloud in a more or less continuous sheet or layer, or in ragged shreds, or a combination of both, but it has *no stratus fractus of bad weather*. The primary difference between L6 and L7 is the presence of *bad weather*. This term refers to the conditions that exist a short time before, during, and after precipitation. Since all stratiform clouds appear greyish and continuous in form, you must be aware of the identifying features of each stratiform type.

1-32. *C_L–7 (stratus fractus or cumulus fractus).* Low cloud type "7" often occurs *below layers of altostratus and nimbostratus,* and it is *classified* as L7 whenever *stratus fractus* or *cumulus fractus* of bad weather are present. When these cloud types

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are present but bad weather conditions *do not* exist, *stratus fractus* clouds are classified as L6 (stratus) and *cumulus fractus* clouds as L1 (cumulus). Foldout 1, L7, shows an example of how the sky appears with these cloud types.

1-33. Ragged stratus fractus clouds never occur alone. They are *always* associated with clouds of low and/or middle types. When they are observed below nimbostratus and similar precipitating clouds, they change shape rapidly and move fast. Stratus fractus and cumulus fractus are usually found beneath the base of cumulonimbus clouds that are precipitating. However, when this situation occurs, only the cumulonimbus cloud type is encoded.

1-34. **Altostratus.** This middle height range cloud has features similar to the lower stratus. The primary difference between altostratus and stratus is the composition of the cloud. An altostratus cloud consists primarily of ice crystals, snowcrystals or flakes, and supercooled water droplets. The lower portion of low altostratus clouds may consist of ordinary water droplets and the upper portion a combination of ice crystals and supercooled water droplets. The composition explains the different features of each cloud.

1-35. Altostratus clouds are generally uniform in appearance. They are greyish or bluish in color and appear fibrous. Other basic characteristics are:

- Altostratus clouds are dense enough to *prevent* objects on the ground from *casting shadows.*
- The sun appears as though seen through *ground glass* when an altostratus cloud is present (foldout 2, M1).
- Halo phenomena *never* occur with altostratus clouds.
- Precipitation is *continuous.*

1-36. Precipitation falling from an altostratus cloud frequently obscures the cloud base. When this occurs, accessory clouds such as cumulus fractus and stratus fractus may form below the altostratus. Figure 4 illustrates this condition. During the hours of darkness, altostratus clouds are even more difficult to identify. At this time, you must watch for such things as a lowering of the ceiling and an increase in the intensity of precipitation. If this happens, you may have nimbostratus. Foldout 2 shows altostratus clouds in the semitransparent state (M1) and in the opaque state (M2).

1-37. Altostratus clouds, as other middle clouds, are found at a height range from 6,500 to 23,000 feet in the temperate region. When they are at the higher levels of this middle cloud range, they are often erroneously identified as cirrostratus because of their lighter appearance. However, if there are no shadows cast on the ground, they are altostratus. Cirrostratus is *never* dense enough to prevent the

Figure 4. Fractus clouds.

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sun from casting shadows. When the altostratus lowers, as during the approach of a warm front, it usually becomes thicker and completely obscures the sun.

1-38. C_M*-1 (altostratus)*. Middle cloud type "1" is an altostratus cloud, the greater part of which is semitransparent. Usually, the sun or moon is dimly visible as though seen through ground glass. This cloud type is usually found within the higher portion of the middle cloud range. This type of altostratus cloud usually forms from the gradual thickening and lowering of a cirrostratus layer. In a later discussion of the basic cloud form cirrostratus, you will discover they are never thick enough to prevent objects from casting shadows because of the sun. Therefore, you can use this rule as a guide in determining whether or not you have altostratus clouds. Foldout 2, M1, shows an example of this cloud type. More rarely, this type of altostratus cloud forms from the extensive spreading out of the middle or upper part of a CB cloud. When altostratus clouds continue to thicken, they are classified as M2 clouds.

1-39. C_M*-2 (altostratus or nimbostratus)*. An altostratus cloud classified as M2 is a *darker grey* or a *darker, bluish grey* than altostratus clouds encoded as M1. The greater part of this altostratus cloud (M2) is sufficiently *dense* to hide the sun or moon. A nimbostratus cloud, which is also encoded as M2, is often caused by a further thickening of dense altostratus.

1-40. **Nimbostratus.** The word "nimbus" is a Latin word that means *violent rain* or *black rain cloud*. Nimbostratus clouds live up to this definition. A nimbostratus cloud produces continuous precipitation in the form of rain, snow, or ice pellets. Usually, this cloud evolves from the lowering of altostratus clouds but may form from other cloud types.

1-41. Nimbostratus is a grey, often dark, cloud that appears diffuse as observed from the ground. This is caused by the continuous precipitation that falls from this cloud. It is *always* thick enough to completely obscure the sun and is almost exclusively found near frontal zones. It is common to find stratus fractus clouds below nimbostratus. These clouds are caused by the falling precipitation from the nimbostratus cloud and tend to completely dissipate when the precipitation becomes heavier.

1-42. Even though nimbostratus is classified as a middle cloud, its base is most often found in the low cloud range. Examples of this are evident as warm fronts approach the station. The altostratus is soon classified as nimbostratus when the cloud increases in density and heavier precipitation occurs. This cloud may continue to lower to within several hundred feet of the surface as the front approaches. Correctly identifying this cloud can alert you to the pattern of weather you can expect at the observation site.

1-43. Nimbostratus clouds are distinguished from opaque altostratus clouds by their denser and darker appearance. The base of a nimbostratus cloud has a more diffuse and wet appearance than an altostratus cloud. However, both of these cloud forms are classified as M2. Nimbostratus clouds usually evolve from the thickening of altostratus clouds but may also evolve from cumulonimbus clouds.

1-44. **Altocumulus.** An altocumulus cloud is composed largely of water droplets, but at very low temperatures it may have some ice crystal development. Altocumulus clouds often look very much like stratocumulus clouds. The primary differences between these two cloud types are the size of the elements and their height. One way to distinguish between altocumulus clouds and other cloud forms is to determine the size of the cloud elements. Extending three fingers at arm's length, the size of the elements should fall within the area covered by your fingers. If they are larger, the cloud is probably stratocumulus. If they do not cover at least one finger, they are probably *cirrocumulus*. This guide is useful only when the cloud elements in question are more than 30° above the horizon.

1-45. When an altocumulus cloud does not have uniformly arranged elements, you must consider other identifying features of the clouds. Altocumulus clouds appear white, grey, or a combination of white and grey. They are in any of the following forms:

- Rounded masses and rolls (such as stratocumulus).
- Banded.
- Semitransparent.
- Lenticular (unusual shaping by the wind).
- Castellated (tufts, turrets, etc.).
- Double layered.
- Dark and thick.

1-46. Of all the basic cloud forms, altocumulus has more varieties. Altocumulus clouds evolve from the lifting of lower clouds or, more rarely, from the thickening and lowering of cirrocumulus. As large cumulus clouds (towering cumulus or cumulonimbus) dissipate, the middle portion of the cloud frequently becomes alocumulus. In this case, your selection of the correct type of cloud has a definite meteorological significance to the forecaster. Foldout 2, M3 through M9, illustrates some typical forms of altocumulus clouds.

1-47. The *virga* phenomenon is common with altocumulus. When it occurs, the precipitation trails appear smaller than those associated with low clouds.

1-48. A *corona* is often present with altocumulus clouds when they are semitransparent. This phenomenon is especially useful to you in determining the type of cloud during hours of darkness. A corona appears as a small ring of light around the moon and appears to blend with a moon's light, whereas a *halo* presents a large distinct circle of light around the moon. Sometimes, a corona displays the rainbow colors faintly. The corona is caused by the diffraction of light through water particles. The diameter of the corona depends on the size of the water droplets in the cloud. Large water droplets produce a *smaller* corona and small droplets produce a *larger* corona.

1-49. C_M*–3 (altocumulus).* Middle cloud type "3" is an altocumulus cloud, the greater part of which is semitransparent. The various elements of the cloud change slowly and are at the same level. This description of M3 clouds does not imply that some of the elements cannot be opaque. Generally this cloud type has some degree of opaqueness, but it is predominantly semitransparent. The elements are relatively small and undergo changes very slowly. This cloud type *does not* progressively invade the sky. Foldout 2 shows an example of M3 from the horizon to overhead.

1-50. C_M*–4 (altocumulus).* Middle cloud type "4" is an altocumulus cloud in patches, and the greater part of it is semitransparent. The cloud elements occur at one or more levels, and the elements *continually change* in appearance. Often this cloud type (M4) appears shaped as an almond or a fish. These unusual lenticular-shaped cloud forms are mostly found near the mountainous regions but may occur at any location. An additional discussion of this lenticular cloud is presented in the section on orographically related clouds.

1-51. C_M*–5 (altocumulus).* Middle cloud type "5," altocumulus, is arranged in semitransparent bands or in one or more fairly continuous layers that progressively invade the sky, as shown in foldout 2, M5. In either case, the main characteristic of M5 clouds is that they generally thicken as a whole. Once the forward edge of the cloud has reached the part of the horizon opposite to that part where the clouds first appeared, the cloud is no longer classified as M5. This is also the case when the forward edge has ceased advancing.

1-52. C_M*–6 (altocumulus).* Altocumulus clouds classified as M6 must have formed from the *spreading out* of cumulus or cumulonimbus clouds. As large cumulus clouds or cumulonimbus clouds dissipate, their remains often consist of large, dark elements. They usually continue to dissipate and thin out to form into separate elements. The best guide to determine the presence of M6 is to view the actual transformation of cumulus to altocumulus. Foldout 2 shows two examples of altocumulus clouds formed by the spreading out of cumulus clouds.

Figure 5. **Altocumulus.**

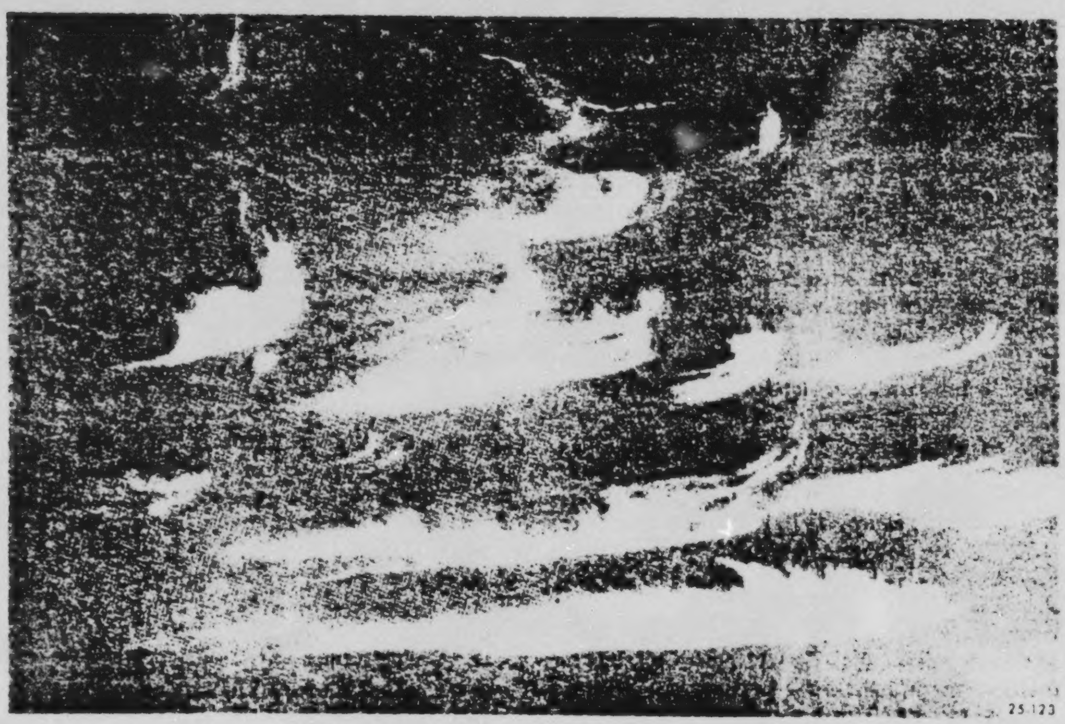

Figure 6. Cirrus.

1-53. *C_M–7 (altocumulus or altocumulus with altostratus).* Middle cloud type "7" consists of altocumulus clouds in *two or more layers.* They are usually opaque in places and do not progressively invade the sky. Middle cloud type "7" also consists of altocumulus clouds together with altostratus or nimbostratus clouds. This cloud type is actually a combination of other middle cloud types. For example, if altostratus (M2) and altocumulus (M3) are present and together, encode the cloud type as "7." Generally the altocumulus elements of this cloud type are *not* changing continually. Foldout 2 shows two examples of altocumulus clouds classified as M7.

1-54. *C_M–8 (altocumulus).* Middle cloud type "8" is an altocumulus cloud with *sproutings* in the form of *small towers* or *battlements.* Figure 5 and foldout 2, M8 castellanus, illustrate the sproutings. Another form of middle cloud 8 is similar to very small cumulus clouds or tufts in the middle cloud range, and it often appears ragged. Foldout 2, M8 floccus, shows this situation. When this cloud has the sproutings in the form of turrets, the cloud is called altocumulus castellanus. A remark such as "ACCAS N–NE" with your observation emphasizes this significant cloud.

1-55. *C_M–9 (altocumulus).* Middle cloud type "9" is an altocumulus cloud form of a *chaotic sky* and occurs at *several levels.* As seen from the ground, this cloud type appears *heavy* and *stagnant.* Meteorologically speaking, altocumulus clouds of a chaotic sky are found near low-pressure areas that contain some storm activity. Foldout 2 shows an example of a chaotic sky. Altocumulus clouds are frequently forced to higher levels in the atmosphere. When this occurs they are called cirriform clouds.

1-56. **Cirrus.** Cirrus clouds generally form between 16,500 and 45,000 feet in the temperature zone. They appear as very white clouds, usually in patches or filaments. The forms of cirrus cloud that is most readily identified is the hook-shaped cirrus. This type of cirrus, figure 6, is in very fine strands which are shaped into the form of a hook by the wind. Foldout 3, H1 through H6, shows eight different types of cirrus cloud formations.

1-57. Cirrus clouds of a denser variety, as shown on foldout 3, H3, frequently evolve from the dissipation of other basic cloud forms such as cumulonimbus. The cirriform remains of a cumulonimbus cloud may spread out to a great extent and completely lose its former identity (anvil shape). Cirrus clouds also form from middle cloud layers that are forced aloft. Cirrus and cirrostratus clouds are often combined in one layer as shown on foldout 3, H5 and H6. When an extensive cirrostratus layer approaches the station from the distant horizon, the leading edge is usually cirrus clouds. As the layer continues to approach, the cloud layer becomes more uniform and usually thickens. This situation is quite common in advance of a warm front.

1-58. Halo phenomena, figure 7, can occur with cirrus clouds, but this is relatively rare. When a halo is present with cirrus, it is usually only a partial halo because of the characteristics of cirrus (strands, filaments, etc.). When the halo is a complete circle, you should suspect the presence of cirrostratus.

1-59. *C_H–1 (cirrus).* High cloud "1" is a cirrus cloud in the form of *filaments, strands, or hooks that do not progressively invade* the sky. This cloud type is often present with other cirrus clouds. In this case, you classify the cloud type as H1 only when the total amount of hooks, filaments, or strands is greater than the combined total of the other cirrus clouds present. Whatever the situation, remember that H1 does not progressively invade the sky.

1-60. *C_H–2 (cirrus).* High cloud "2" is a *dense cirrus* cloud that is *in patches* or *entangled sheaves* which usually do not increase in size and which sometimes seem to be the remains of the upper part of a cumulonimbus. An H2 cloud can also be cirrus with sproutings in the form of small *turrets* or *battlements* or cirrus having the appearance of cumuliform tufts. This dense cirrus cloud does not originate from cumulonimbus clouds, although the patches are sometimes rather opaque and have borders of entangled filaments. This can give the erroneous impression that the cloud patches are the remains of cumuliform clouds. When an H2 cloud is present with other cirrus clouds, the H2 characteristics must predominate for the clouds to be encoded as such. H2 and H3 clouds are often mistaken for each other. When it is certain that the cloud evolved from a cumulonimbus cloud, the cloud is classified as H3.

1-61. *C_H–3 (cirrus).* High cloud type "3" is a *dense* cloud that is often in the form of an anvil, which is the remains of the upper parts of a cumulonimbus cloud. The best guide to classify this cloud type is to observe the upper part of a cumulonimbus cloud as it transforms into dense cirrus. However, if you have sufficient evidence that the dense cirrus cloud evolved from cumuliform clouds, you may classify dense cirrus clouds as H3 even though you do not actually see the transformation. This evidence may come from pilot sightings of cumulonimbus clouds near your area or the unmistakable features associated with the dissipation of cumuliform clouds (M6 for example).

1-62. *C_H–4 (cirrus).* High cloud type "4" is a cirrus cloud in the form of hooks and/or filaments that progressively invades the sky and becomes more dense. This cloud type is very similar to H1

Figure 7. Halo.

except that an H4 cloud progressively invades the sky and becomes more dense. These clouds appear to fuse together near the horizon where they first appear, but no cirrostratus clouds are present. When cirrostratus conditions are present, you should examine the clouds closely to determine whether or not to classify the type as H5.

1-63. **Cirrostratus.** A cirrostratus cloud is a whitish veil very similar in appearance to cirrus clouds. The primary difference is the great horizontal extent of cirrostratus and its more veil-like appearance. Cirrostratus clouds usually produce a halo when the cloud composition is thin enough. Cirrostratus often appears as altostratus on the distant horizon. In this case, you should consider the speed of movement of the cloud (a cirrostratus cloud appears to move more slowly) and the slower changes in form and appearance that are characteristic of cirrostratus. Cirrostratus clouds on the horizon are sometimes confused with haze. You can distinguish the haze by its dirty yellow-to-brown color.

1-64. A cirrostratus cloud is never thick enough to prevent objects on the ground from casting shadows when the sun is higher than 30° above the horizon. Observing the effect that the sun has on cirrostratus can be one of your greatest aids in determining the type or presence of cirrostratus clouds. For example, a cirrostratus layer may be so thin that only the presence of a halo reveals its presence, as shown in foldout 3, H7.

1-65. As a cirrostratus cloud advances from the horizon, you can use it as an indication of an approaching front. This cloud type is often observed several hundred miles in advance of a warm front. This is caused by the slow ascent of air to the higher levels (up the warm front slope). Cirrostratus also forms from the thinning and rising of altostratus layers or from the dissipation of an extensive cumulonimbus formation.

1-66. *C_H–5 (cirrus and cirrostratus or cirrostratus alone).* High cloud type "5" is cirrus and cirrostratus clouds or cirrostratus clouds only. (The cirrus clouds are often in bands converging towards one point or two opposite points of the horizon.) In either case, they progressively invade the sky and generally grow more dense, but the continuous veil does not reach 45° above the horizon. Usually, the leading edge of this cloud type is in the form of cirrus filaments or hooks and, occasionally, resembles the skeleton of a fish. When this cloud type progresses to 45° above the horizon, it is classified as H6.

1-67. *C_H–6 (cirrus and cirrostratus or cirrostratus alone).* High cloud type "6" has the same appearance and features of H5 but extends to more than 45° above the horizon, without the sky being totally covered. Similar to H5, it progressively invades the sky and grows more dense. When the cloud layer covers the entire sky, it is classified as H7.

1-68. *C_H–7 (cirrostratus).* High cloud type "7" is a veil of cirrostratus clouds covering the celestial dome. This cloud is uniform in structure, showing few distinct details. On occasion, the continuous veil of H7 is so thin (transparent) that the only indication of its presence is a *halo* phenomenon. When lower clouds obscure parts of an overcast cirrostratus layer, you may still classify it as H7 if you have evidence that the layer covers the sky. If the cirrostratus layer does not cover the sky, classify the cloud type as H8.

1-69. *C_H–8 (cirrostratus).* High cloud type "8" is cirrostratus which is not or is no longer progressively invading the sky and which does not completely cover the celestial dome. When H8 is present with other cirriform cloud types, it must be predominant to be classified as H8. Though the definition of this cloud type specifically states that the cirrostratus clouds are not progressively invading the sky, this refers to the continuous veil form of the cirrostratus formation. When cirrostratus is in patches (not cirrus), H5, H6, and H7 are not appropriate classifications. Classify patches of cirrostratus as H8 *regardless of whether they are increasing,* even though cirrus and cirrocumulus clouds may also be present but not predominant.

1-70. **Cirrocumulus.** Cirrocumulus clouds (H9) are very much like the regularly arranged elements of high altocumulus clouds. The basic difference, however, is their size and composition. To be cirrocumulus clouds, the element must have an apparent width of less than 1°. You can measure this by extending your little finger at arm's length. If the element you are evaluating is not larger than your finger, the cloud type is probably cirrocumulus. Again, this guide is only reliable when the cloud element is higher than 30° above the horizon.

1-71. Cirrocumulus clouds consist primarily of ice crystals, but they can also consist of minute supercooled water droplets that are usually replaced rapidly by ice crystals. Cirrocumulus clouds are observed with a slight corona phenomenon which adds to the beauty of the cloud. When this cloud is present, the sky is often referred to as a *mackerel* sky because of the cloud layer's resemblance to the scales of a fish. Some observing terms used to identify this cloud are *pebbles on a beach, honeycomb, and neilike.*

1-72. Some forms of cirrocumulus clouds are similar to altocumulus castellanus clouds. They appear as small tufts or turrets; however, they must be less than 1° in width to be classified as cirrocumulus. Foldout 3, H9, shows an example of cirrocumulus development with other cirriform clouds. Some of the elements appear so small that they are difficult to discern with the naked eye.

1-73. High cloud type "9" is cirrocumulus clouds by themselves or accompanied by cirrus and/or cirrostratus clouds, but the cirrocumulus clouds *must be predominant*. Be sure that you remember that the elements of cirrocumulus must have an apparent width of less than 1°. Before discussing encoding of the cloud types already mentioned, let's look at the names and identifying features of some mountain wave clouds.

1-74. **Orographic Cloud Forms.** Certain types of clouds are formed as a result of air moving over rough terrain. These clouds indicate the presence of a mountain wave condition in the atmosphere; therefore, they are significant in flight operations. A mountain wave condition consists of turbulent air and strong updrafts and downdrafts. Flight operations in these conditions pose a serious threat to flight safety. As a weather observer, it is important that you recognize and report these unusual clouds.

1-75. The most common orographic clouds belong to the same class as altocumulus, stratocumulus, and cumulus clouds. Listed below are the orographically produced clouds that are related to a mountain wave.

- Lenticular—altocumulus.
- Rotor (roll)—cumulus.
- Foehnwall (cap, collar)—stratocumulus.

1-76. *Lenticular*. The lenticular cloud is an altocumulus cloud (M4) which is almond or fish-shaped. The cloud is observed in patches at one or more levels, and the elements are continually changing in appearance but generally remain stationary in spite of the high wind speeds. They constantly form on their windward side and dissipate on their downwind side. Since the cloud patches are of limited horizontal extent and their elements are continually changing, these clouds are usually semitransparent rather than opaque. The patches, as a whole, may have the form of large lenses and are *not* progressively invading the sky. Foldout 2, M4, shows an example of standing (stationary) lenticular clouds.

1-77. *Rotor*. Rotor clouds are cumuliform in appearance and are found on the leeward side of the mountain range. Rotor clouds, similar to lenticular clouds, are stationary and are constantly forming on their windward side and dissipating on the leeward side. Because of their vertical development and cumuliform appearance, they are usually encoded as low cloud type "2."

1-78. In addition to classifying the lenticular and rotor clouds for cloud code group encoding, you must append remarks concerning these clouds to your weather observation, such as the following:

ACSL OVHD AND W
FEW ACSL FORMG W-NW
APRNT ROTOR CLDS OVR MTNS

The first remark indicates that you observed altocumulus (AC) standing lenticular (SL) overhead (OVHD) and to the west (W) of your station. In the second and third remarks, "FORMG" is the contraction for *forming* and "APRNT" is the contraction for *apparent*.

1-79. *Foehnwall*. The foehnwall cloud is stratocumulus in appearance and is usually classified as low cloud type "5." This cloud hugs the top of the mountain and sometimes flows down the leeward side of the mountain, producing the appearance of a waterfall. This concludes the discussion of basic and international cloud types and their characteristics. However, cloud recognition and identification is only part of your job. You must know how to encode the cloud types so that your observation can be sent to other weather stations and weather centrals.

1-80. **Encoding $1C_LC_MC_H$ Group (Column 13).** Each 3- and 6-hourly observation must have a cloud code group appended to it. Of course when the sky is *clear* or *completely hidden* by surface obscuring phenomena, a cloud code group is not appended. The $1C_LC_MC_H$ group is entered in column 13 of AWS Form 10. (The sequence of entry for observations is discussed in a later section of this text.) Presently, the concern is how to encode the cloud types correctly.

1-81. Whenever there is only one cloud type present for each cloud division of the atmosphere (C_L, C_M, and C_H), you merely enter the correct type for each division. If no clouds are present in a division, enter a zero for that division. Whenever you have more than one cloud type in a division, you select the type that is the most significant. Table 1 shows the order of priority for encoding clouds in the $1C_LC_MC_H$ group.

1-82. Suppose you determine that the following cloud types are present during a state-of-the-sky evaluation:

C_L-2 (towering cumulus)
C_L-5 (stratocumulus at a different level)
C_M-3 (altocumulus)
C_H-1 (cirrus)
C_H-8 (cirrostratus)

How is this cloud observation encoded for the cloud group entry in column 13 of AWS Form 10?

1-83. Table 1 shows that L2 takes priority over L5 when low cloud types are encoded. But it is not as simple as this. Generally, you enter the code of the cloud type that has priority; however, when L2 and L5 are both present (at different levels), the low cloud type is classified as L8. This example for encoding low cloud types illustrates the importance of knowing the definitions of the 27 international cloud types. An inexperienced observer might select L2 for encoding. Only one middle cloud (M3) is present in this example; therefore, the cloud group code is 183 to this point. The cirriform cloud types are classified as H1 and H8; therefore, you need to determine from table 1 which high cloud must be encoded. In this case, high cloud "8" takes priority over H1. The correct entry in column 13 of AWS Form 10 for this particular state of sky is 1838. Make the forecaster aware of the presence of towering cumulus by the remark "TCU" in column 13.

1-84. When lower clouds form an overcast layer, thereby obscuring middle and/or high cloud layers, the encoded values for the obscured layer(s) should be entered as a solidus (slant line) as shown in the following examples:

15//
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The solidus is only used when the low or middle overcast layer has 10/10 opaque sky coverage. BINOVC (breaks in overcast) is considered as 10/10. The cloud code group is just one method of recording state-of-the sky evaluations. Another method is to encode the state of the sky according to layers, amounts, and heights on AWS Form 10.

1-85. At this point, take a break and answer the chapter review exercises in your workbook for Section 1.

2. Ceiling and Sky Condition

2-1. Determining the sky condition is largely subjective and requires, above all, practical experience. There is one important reason for a careful evaluation of the sky. Almost all changes in surface weather are preceded or accompanied by clouds. For example, frontal passages give advance warning of their presence by a series of changes in clouds and sky condition. The forecaster interprets the significance of these changes from your ob-

TABLE 1

ORDER OF PRIORITY FOR ENCODING $1C_LC_MC_H$ GROUP

Order of Priority	Low Cloud C_L	Middle Cloud C_M	High Cloud C_H
1st	9 CB (anvil)	9 AC(chaotic)	9 CC (predominant)
2nd	3 CB	8 AC(turrets)	7 CS (covers sky)
3rd	4 SC (from CU)	7 AC(with AS or NS)	8 CS(not covering or invading)
4th	8 SC & CU	6 AC(from CU)	6 CS(invading, over 45°)
5th	2 CU(large)	5 AC(invading)	5 CS(invading, less than 45°)
6th	1 CU	4 AC(changing)	4 Cl(invading)
7th	5 SC(not from CU)	7 AC(two levels)	3 Cl(from anvil)
8th	6 ST	7 AC(opaque)	2 Cl(dense patches predominant)
9th	7 STFRA, CUFRA	3 AC(semi-transparent)	1 Cl(filaments predominant)
10th		2 NS or AS	
11th		1 AS (semi-transparent)	

TABLE 2
SKY COVER SYMBOLS

SYMBOL	DEFINITION
○	Clear (CLR) - 0.0 total sky cover.
⦶	Scattered (SCTD) - 0.1 to 0.5 sky covered.
⦷	Broken (BRKN) - 0.6 to 0.9 sky covered.
⊕	Overcast (OVC) - 1.0 (ten tenths) sky covered.
—X	Partly obscured - 0.1 to 0.9 sky covered by surface based obscuring phenomena.
X	Obscured - 1.0 (ten tenths) sky covered by surface-based phenomena.

servation. Your training in making surface observations prepares you to recognize and record the details of the changing sky.

2-2. Sky condition is observed and evaluated in layers. During observation, you consider *amount, transparency,* and *height* for each layer. Looking, then, at a series of observations, you can see sky cover transitions by the changes in the observed layer. A change in amount of a layer from 0.8 to 0.6 may appear unimportant from one observation to the next. However, when this minor change is regarded within a trend and in relation to all the other sky data, an approaching weather situation may be foretold. In observing the sky condition, first you consider the layers of sky cover.

2-3. **Layers.** A layer is defined as *clouds or obscuring phenomena which have bases at the same approximate level.* A layer may appear as continuous cover, such as stratus, or it may appear as detached elements, such as fair-weather cumulus. Also, both continuous and detached elements may combine to form a layer. The essential requirement is that their bases be at the same approximate level. The upper portions of a cumulonimbus cloud are often spread horizontally by wind and form dense cirrus or altiform clouds. These horizontal extensions of the cumulonimbus clouds are regarded as separate layers only if their bases *appear horizontal* and at a different level from the parent cloud. Otherwise, the entire cloud system should be regarded as a single layer at a height corresponding to that of the base of the cumulonimbus. A layer can be a combination of cloud types or obscuring phenomena at the same level. Obscuring phenomena, such as haze, are often present in the atmosphere but are not considered as a layer unless they have an apparent base. Having divided the state of the sky into layers of clouds, obscuring phenomena, or both, next determine the amount of each layer.

2-4. *Amount.* Though you observe the amount of sky covered by each layer in terms of *tenths of sky,* symbols are used to describe the sky cover. Table 2 gives the sky cover symbols and their meaning. These sky cover symbols are entered in column 3 of AWS Form 10 for each layer of clouds or obscuring phenomena—surface-based or not. Each symbol represents the portion of the sky that is *covered at that layer and below.* Figure 8 illustrates this "at the below" concept of assigning sky cover symbols. The difference between layer and sky cover also is shown.

2-5. In figure 8, the first layer (2/10 stratus) is entered in column 3 of AWS Form 10 as a scattered symbol (⦶). This 2/10 amount also repre-

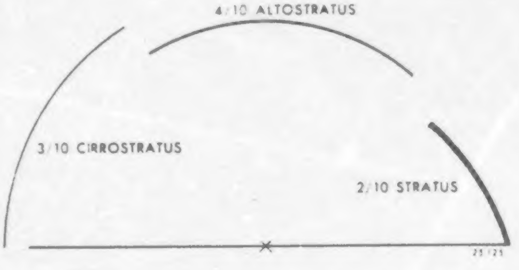

Figure 8. Layer and sky cover.

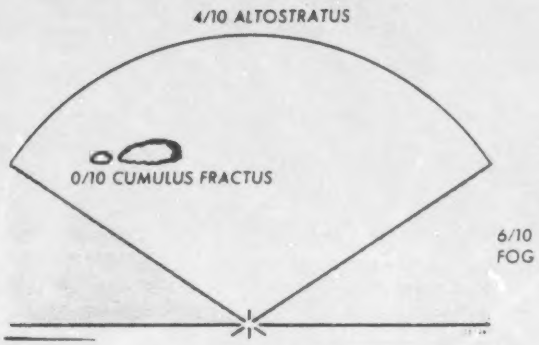

Figure 9. Surface-based sky cover.

sents the total sky cover at this level. The next layer tells a different story. Though the altostratus covers 4/10 sky *as a layer,* the total *sky cover* up to this point is 6/10 because of the combined amounts of the first two layers. Thus, the symbol for the altostratus layer is ⦶ (broken) because of the concept described as "at and below" sky cover. The highest layer (3/10 cirrostratus) is also assigned a broken symbol because the combined total equals 9/10 sky cover.

2-6. You can understand how meaningless it would be to enter three separate scattered symbols in column 3 to report these individual layers. To a pilot flying above the highest layer and looking for ground navigational aids, your report of "scattered" sky cover would hide 9/10 of the ground from his view. By reporting a broken sky cover, you have more accurately described the sky condition to the pilot.

2-7. Symbols for reporting surface-based obscuring phenomena are also provided. Table 2 shows that a −X symbol describes a partly obscured condition. Figure 9 shows another typical sky condition. What sky cover symbols are entered in column 3 of AWS Form 10 for this example? If you selected −X for the first layer, ⦶ for the next layer (cumulus fractus), and ⊕ for the highest layer, you are correct. Figure 9 illustrates two principles. First, the 6/10 fog, even though surface based, hides sky just as if it were a cloud aloft. Second, the 0/10 cumulus fractus must be treated as a layer. Even though this layer covers less than 0.1 sky, it is a layer by definition and also meets the criteria for broken sky cover. This is true because the total at and below that level (including the 6/10 fog) hides enough sky to require the broken symbol.

2-8. Once more the difference between a layer and sky cover is compared. A cloud may qualify as a layer, yet not cover enough sky (0/10) to qualify as sky cover. Consider, for example, a 0/10 layer of cumulus by itself. You cannot ignore it as a cloud (thus also a layer), but the column 3 (AWS Form 10) sky cover, by definition, must be clear, ○. The presence of the 0/10 layer can then be remarked in column 13.

2-9. When sky cover layers are advancing or receding on the horizon, you use the left-hand column of table 3 as a guide to determine the number of tenths of the sky that is covered by a layer.

TABLE 3
SKY COVER AMOUNTS

Angle of Advancing or Receding Layer Edge	Tenths of Sky Cover	Angular Elevation of Layer Surrounding Station
0° to 25°	0	0° to 2°
26° to 45°	1	3° to 8°
46° to 59°	2	9° to 14°
60° to 72°	3	15° to 20°
73° to 84°	4	21° to 26°
85° to 95°	5	27° to 33°
96° to 107°	6	34° to 40°
108° to 119°	7	41° to 48°
120° to 134°	8	49° to 58°
135° to 154°	9	59° to 71°
155° to 180°	10	72° to 90°

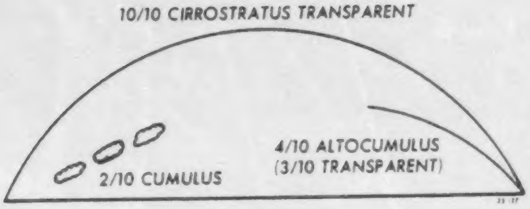

Figure 10. Thin sky cover.

When a layer of sky cover surrounds the station, use the right-hand column of table 3 as a guide to determine the number of tenths of sky coverage. Table 3 takes much of the guesswork out of estimating sky coverage at difficult angles of observation.

2-10. During your observation of sky cover, be alert for layers that occur directly beneath another layer. In this case, you cannot add the amounts of both layers to arrive at total sky cover because they hide the same section of the sky; for example, when 0.3 of cumulus is *below* 0.5 of altocumulus. Together these two layers *hide 0.5 of the sky* and, therefore, are both scattered layers. The few samples discussed here help to illustrate the layer versus sky cover principle and entries for sky cover amounts. Another feature that you must consider when observing sky condition is the transparency of the layer.

2-11. *Transparency.* This fancy term means "capable of being seen through." A window is transparent. Opaque is the opposite of transparent. We designate sky cover as either transparent or opaque. Occasionally, when we talk about certain clouds, such as altocumulus, we use the term semitransparent. That is a proper and accurate description—for clouds. For sky cover it is *not* proper. These semitransparent layers, though they permit the passage of light, do not permit a clear picture of higher layers. Therefore, for practical purposes, consider them opaque when you are deciding between transparency and opaqueness for encoding purposes.

2-12. To accurately encode transparent sky cover, you must again recognize the difference between a layer and sky cover. That is, the "at and below" concept importantly affects your decision. Transparent layers are classified as *thin.* The lowest layer can be classified as *thin* only when the transparency equals 1/2 or more of the total layer amount. For example, a layer of stratus that covers 0.6 of the sky but is 0.3 transparent is classified as *thin.* Column 3 entry (AWS Form 10) would be −⦷. The minus (−) sign indicates that the layer is thin enough to reveal higher clouds or sky above.

2-13. When you observe multiple layers, use the "at and below" concept to obtain "total" opaque and transparency amounts. Figure 10 shows an example of opaque and transparent layers coexisting in the sky. To solve this problem, start with the lower layer and work up. Let's arrange the amounts for each layer in order and add the transparency totals for each layer. You can count three layers in figure 10; thus you need three sky cover symbols. As you add each layer to the total sky cover, the first layer is ⦶, second ⦷, and third ⊕. Decide now, at which layers the sky cover is thin. Below, you can see the information for each layer arranged in table form.

Layer	*Amount*	*Total Opaque*	+	*Total Transparent*	=	*Total Sky Cover*	*Sky Cover Symbol*
1st	0.2	0.2		—		0.2	⦶
2nd	0.4	0.3		0.3		0.6	− ⦷
3d	1.0	0.3		0.7		1.0	− ⊕

It is easy to see that the total *transparent* sky cover becomes 1/2 of the total sky cover at the second layer. It, then, is reported as thin broken (−⦷). The sky cover remains thin at the third layer. This is so because the transparent sky cover is well over 1/2 of the total cover.

2-14. It is possible to report more than one overcast symbol in column 3. The only rule to observe in this case is that only the highest layer may be classified opaque. The lower overcasts *must* be thin. As a final step in reporting sky cover, you ascribe a height to each reported layer.

2-15. *Height.* Heights of layers must be reported according to established reportable values. Table 4 shows the reportable values that can be entered in column 3. For example, during an evaluation of sky cover, suppose you detect four opaque layers:

0.2 Surface-based fog.
0.3 Stratocumulus at 4,780 feet.
0.0 Altocumulus at 9,300 feet.
1.0 Altostratus at 16,500 feet.

If you use table 4 correctly, the height entries in column 3 for each layer should be: −X48⦶95⦶160⊕. This example does not indicate a ceiling designator which we will discuss separately. Notice that the last layer (altostratus) is exactly halfway between two reportable values. In this case, select the lower value.

2-16. In the above example, each height represents the base of the layer above the surface.

TABLE 4
SKY COVER HEIGHT VALUES

Feet	Reportable Values (Coded in Hundreds of Feet)[1]
5000 or less	To nearest 100 feet
5001 to 10,000	To nearest 500 feet
Above 10,000	To nearest 1,000 feet

[1] Code heights that are halfway between reportable values as the smaller of the two values.

There is one situation when height represents the vertical visibility into the layer. This applies only to a surface-based layer completely obscuring the sky (X). Since this layer is a ceiling, the discussion of how to obtain its height is discussed later.

2-17. For all sky coverage, whether scattered, broken, or overcast—ceiling or nonceiling—thin or opaque—clouds or obscuring phenomena, you must use the height that is obtained from the most reliable method. Several methods are available for obtaining heights. You must take into consideration not only the reliability of the height data but also the distance from the observation point, the height of the layer, and the time of observation. Do not enter in column 3 (Form 10) the method by which you obtained the height measurement, unless you have a broken or overcast layer that is classfied as a ceiling. However, the same rules for obtaining heights apply for all layers, regardless of amount. When finally you have the amounts, transparency, and heights of the layers, your last decision involves the sky cover ceiling.

2-18. **Ceilings.** A ceiling is the height ascribed to the lowest opaque layer of clouds or obscuring phenomena aloft that is reported as broken or overcast; or the vertical visibility in a surface-based phenomenon that obscures the sky. In many cases, ceiling layers are the principal controlling factor for aircraft departures, landings, or the diversion of aircraft to another field. Low ceilings demand the most accurate measurements possible. Sometimes a difference of 100 feet in the ceiling layer determines whether or not an aircraft can land or whether the pilot must seek an alternate field. Therefore, two important responsibilities in observing sky conditions are, first, to correctly judge the presence of 0.6 sky coverage and, second, to assign an accurate height to the ceiling layer.

2-19. In column 3 of AWS Form 10, ceiling heights are provided with a ceiling designator. These letter designators (listed below) indicate the method by which you obtain the ceiling height.

Designator	*Meaning*
M	Measured ceiling
R	Radar ceiling
A	Aircraft ceiling
B	Balloon ceiling
E	Estimated ceiling
W	Indefinite ceiling

The list above is in descending order of reliability. Normally, the rotating beam ceilometer is used for determining layer and ceiling heights or vertical visibility. But the ceilometer has limitations. Then use the most reliable and possible alternative method. Let us investigate the methods of obtaining heights to see how and when each one should be used.

2-20. *Measured.* Ceiling heights are prefixed with an "M" designator whenever they are obtained by a *ceilometer, ceiling lights,* or *known heights of isolated objects* (towers, smoke stacks, etc.) within 1½ nautical miles of the airfield. Values obtained from either the ceilometer or ceiling light must be less than 10 times the baseline to be classified as a measured ceiling. During ceilometer outage, you may use the ceilometer on an alternate runway—under one provision. Using your judgment, the measurements must be representative of conditions on the active approach. The best measurements are those which average as many angular readings as possible during the period of observation.

2-21. *Radar.* The "R" ceiling designator pertains to height measurements from cloud detection radar. Storm detection or weather surveillance radar cannot be used for an "R" ceiling. The reliability of the TPQ–11 cloud detection radar has been discussed earlier in Volume 1, Chapter 3. From that discussion you are aware that you must carefully consider the radar values you obtain. Supplement them with any other method available if the values appear nonrespresentative.

2-22 *Aircraft.* Ceiling heights reported by a pilot qualify as "A" designated ceilings. Not all aircraft reported ceilings can be considered valid for your station because of distance or time of observation. Therefore, to use the "A" designatc: with cirriform layers, the report must be within 50 nautical miles of the airport and 1 hour of the observation time. Noncirriform layers must be observed within 1½ nautical miles of the airport runway and also within 15 minutes of the actual time of an observation. If you receive an aircraft ceiling and are unsure of its distance from your station or its value as a ceiling height, do not use it. When you use an aircraft height in column 3, convert it from an MSL height to a height above surface.

2-23. *Balloon.* A balloon ceiling is based on either a pilot, ceiling, or raob balloon ascension. Ascension rates are expected to be fixed by the amount of lift given to the balloons. Proper balloon inflation (neither over nor under inflation) controls this important aspect. The known ascension rate is compared to the length of time between release and entry of the balloon into the layer. The point of entry is midway between the time the balloon first begins to fade and the time of complete disappearance. Then you compare the observed time with prepared tables that are computed for the various size balloons. In the case of a raob balloon, the time is compared to the pressure-height data of the radiosonde observation.

2-24. Ascensional rates must be closely watched. Anything that changes the rate makes the prepared tables incorrect. A lighting device, for instance, attached to a pilot balloon affects the accuracy. Ascensional rates of ceiling or pilot balloons are unaffected by drizzle of any intensity. Since you must watch the balloon carefully to detect its point of entry, choose a balloon color that can best be watched under the situation. *Red* balloons are usually the best to use with *thin* layers and *blue* or *black* balloons under other conditions. A stopwatch or sweep second-hand also makes determination of the correct time easier for you. Whenever the accuracy of the balloon ascension is in doubt, the ceiling is designated as "E."

2-25. *Estimated.* An "E" ceiling covers all the cases where the method used to find the height was considered unreliable. As pointed out during the balloon ceiling discussion, a lighting device attached to a pilot balloon affects the ascensional accuracy. A ceiling derived in that manner is an "E" ceiling. Moderate to heavy rain or snow, hail, or any intensity of ice pellets and freezing rain during balloon ascension also makes an "E" ceiling. Any cirriform ceiling height obtained by M, A, R, or B method which is also between 1 and 6 hours old should be classed as an "E" ceiling. Of course, no evidence of change in height from the original value must exist.

2-26. Heights obtained from ceilometers or ceiling lights that are equal to or greater than 10 times the baseline must be classed as estimated. Also, if you use the known height of a landmark or tower situated more than 1½ nautical miles from the runway, call the height estimated.

2-27. The RHI scope of the storm detection radar is not a good indicator of cloud heights, especially in the low or high cloud ranges. Heights obtained by this method are classed "E." You should not assume from this discussion that "E" classed ceilings are inaccurate. They *can* show a good degree of accuracy. However, they simply do not meet the strict standards of *reliable* measurement that are required of a ceiling height evaluation.

2-28. Two common methods of obtaining ceiling heights fit the above description. The first of these, the convective cloud height diagram, allows you to estimate the heights of convective type clouds with relative accuracy if certain considerations are met, as follows:

a. Clouds are formed near the observation point (local heating involved).

b. Local terrain is not mountainous or hilly.

c. Clouds are at or below 5,000 feet.

d. Recent dewpoint and free air temperature readings are available.

You can use the diagram in figure 11 to estimate the base of convective clouds. Locate the dewpoint temperature at the base of the diagram (vertical solid lines) and the dry-bulb temperature (sloping solid lines), and follow these lines to the point where they intersect. Follow this point horizontally to the right side of the chart, and read the estimated cloud height. This value represents the base of the convective clouds at your station. For example, assume that you have a dewpoint reading of 57° F and a temperature of 73° F. The estimated cloud height is approximately 3,800 feet. One important fact to remember when you use this method to determine cloud heights is that as changes in the dewpoint and temperature occur, you must make new computations of the height.

2-29. The second method of obtaining estimated ceilings is probably the most frequently used; that is, using your own experience concern-

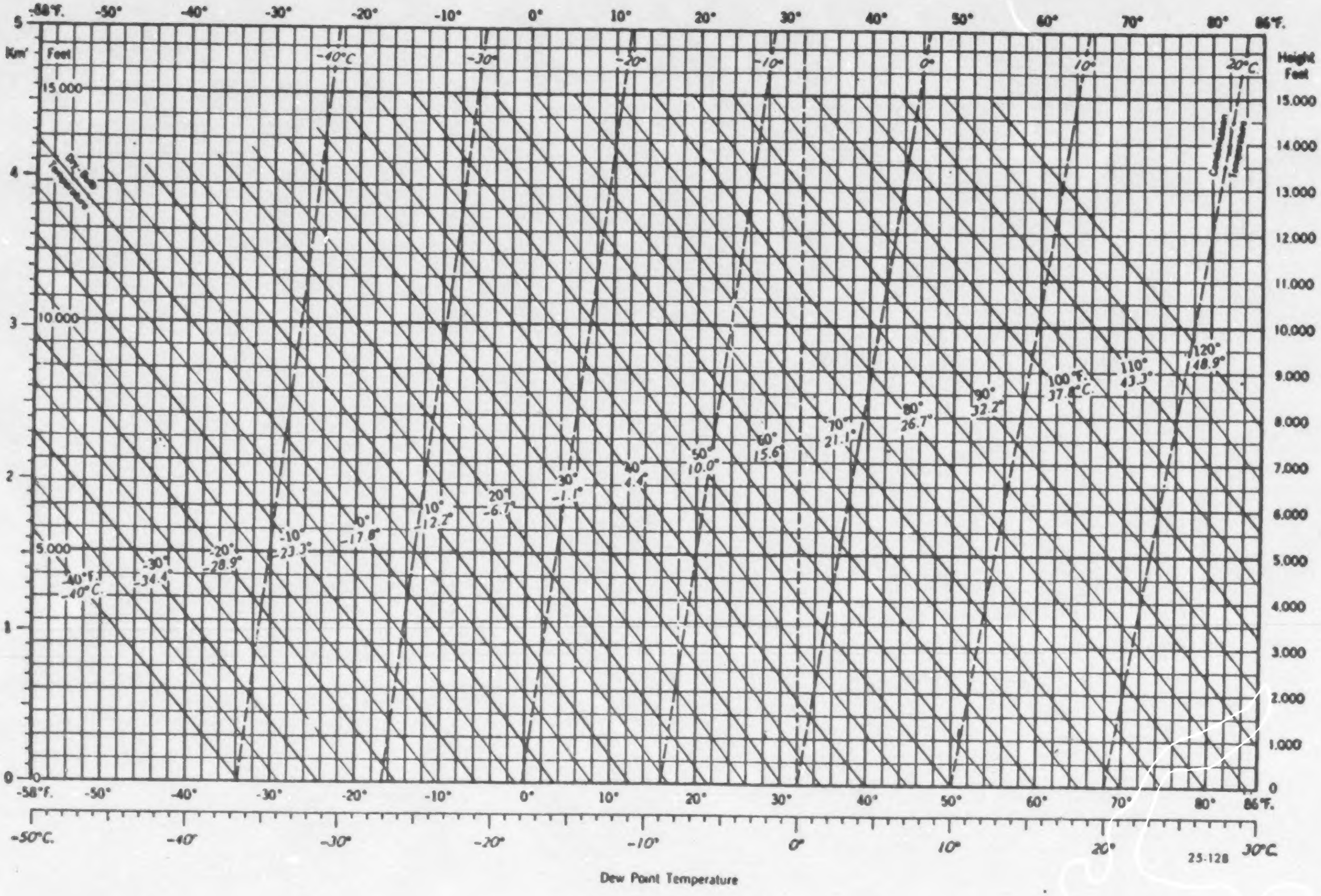

Figure 11. Convective cloud height diagram.

ing cloud types and sky conditions to make an estimation of height. Your estimations should be checked, whenever possible, against a reliable method of measurement. This comparison furnishes you with an idea of whether you usually estimate high or low under different conditions of sky cover amount and background.

2-30. *Indefinite.* The "W" ceiling represents a vertical visibility into a surface-based obscuring phenomenon. This vertical visibility may be obtained from a pilot looking downward into the obscuration. However, his observation must be within 1½ nautical miles of the runway and within 15 minutes of actual observation time to be a valid "W" ceiling. Other ways to obtain vertical visibilities are from the upper portion of a ceilometer reaction, the top of a ceiling light projector beam, or the height at which a balloon completely disappears. Visible portions of buildings or towers may aid your judgment in obtaining a vertical visibility.

2-31. The column 3 (Form 10) entries for sky condition reveal the number of layers, amount of sky cover, transparency, height, and ceiling height. All this data is described by means of a simple entry such as M20⦷. You may further describe the sky condition by adding remarks.

2-32. **Ceiling/Sky Remarks and Entries.** Some facts that the standard column 3 entries do not reveal are ceilings that vary in height or amount, heights of cloud bases and tops not visible from the station, significant clouds, or other significant features about the sky cover. This significant information is added, when necessary, to the airways observation. First of these in our discussion is the variable ceiling.

2-33. *Variable ceiling.* Variable ceiling is a term that describes a condition in which the ceiling rapidly increases and decreases by one or more reportable values while the ceiling observation is being taken. Rapid fluctuations of the ceiling indicate an irregular base; therefore, the height is variable. A variable ceiling is reported only when the *ceiling is less than 3,000 feet.* The height of the ceiling is the average of all the observed values. A variable ceiling is not based on rapid fluctuations of the instrument readings alone. Visual observation is needed to exclude the possibility that the fluctuation is caused by separate layers.

2-34. To enter a variable ceiling, average the readings obtained during the ceiling observation. Enter the average (use reportable values only) as the ceiling height in column 3. This average value is *suffixed* with the letter "V" to indicate that the ceiling is variable; for example, M15V⊖. Whenever you make a variable ceiling entry, you must enter a remark for the *lowest* and *highest* value of ceiling variability, such as CIG 11V19, in column 13. When considered together, the entries M15V⊖ and CIG 11V19 make a complete description of the ceiling layer.

2-35. *Variable sky cover.* The amount of sky cover occasionally varies between reportable values. Variable sky cover may occur at any level not necessarily at the ceiling layer. Nothing need be remarked when a layer varies in amount from 4/10 to 5/10, for instance. Both amounts qualify as scattered. Remark those amounts that vary between reportable values—5/10 to 6/10 (scattered to broken). The variability may go from ⦷ to ⦶, too. Whatever the situation, enter the symbols separated by a "V"—⦶V⦷. Prefix a height to those layers that might easily be confused with another layer of like amount—15⦶V⦷. Other significant information pertains to sky cover not visible from the station.

2-36. *Bases and tops of layers.* Whenever radar or pilot reports provide information on the bases of layers that are *not visible* at the station and on tops of layers, they should be entered in column 13 if the reports meet the following criteria:

- They are within 20 nautical miles for noncirriform clouds.
- They are within 50 nautical miles for cirriform clouds.

Each base or top is separated from other data and other layers by a slant line. The heights are entered in hundreds of feet MSL. When the report is more than 15 minutes old but is considered operationally significant, precede the report with the time (GMT). The following are some typical examples of how cloud bases and tops are reported in column 13:

/75⦶/150⦷220/
/60⊖/80/1733 U330/
/1807⦶110/220U/

The "U" indicates an unknown (or unreported) height.

2-37. To enter base and top information from radar sources, prefix the reports with the contraction RCD (radar cloud detection):

/RCD75U/150U220/
/RCD⦷65/0918 130U180/

When radar and pilot reports are mixed, use the RCD and PIREP contractions to separate them. These reports of cloud bases not visible, or of tops of layers over the station, add meaning to standard sky condition entries in column 3.

2-38. *Sky condition remarks.* There is such a variety of sky conditions to be reported that the column 3 entries, though they provide much information, alone cannot give the whole picture. You should add remarks for the significant sky features observed.

2-39. Operationally significant remarks are remarks that you consider to be important to planning and conducting flight operations. At most stations, certain cloud formations and movements are of no particular significance. However, at a coastal station or in a mountainous area, certain cloud types reveal significant features about impending changes in the ceiling, visibility, or weather in general. By reporting these operationally significant remarks with your observation, you add greater meaning to other entries. Use authorized contractions or plain language, when necessary, with operationally significant remarks. Some observers hesitate to encode these remarks because of the increased chance of making errors. This, of course, is not the correct nor desired attitude. Add remarks that are significant, but phrase the remark so that it does not resemble a forecast. The more common sky condition remarks are discussed in the following paragraphs.

2-40. The following remarks deal with openings or holes in the sky cover.

a. HIR CLDS VSB—reported when higher (HIR) clouds (CLDS) are visible (VSB) through breaks in an overcast that is not classified as thin.

b. BRKS—used for a broken ceiling layer that is below 1,000 feet and is followed by the direction of breaks (BRKS) from the station. For example, BRKS N or BRKS OVR MMKR (middle marker).

c. VINOVC—reports breaks in an overcast layer not classified as thin. No higher clouds are visible. Follow the contraction with the direction from station—BINOVC E.

2-41. The remark "BRKS" for a broken layer below 1,000 feet is very important to flight operations. This remark discloses to the pilot the location of the clear area in the broken layer. When you know the direction from the ROS to the middle marker (radio instrument used for landing), you can report "BRKS OVR MMKR" when the remark is appropriate. The middle marker is significant because it is located off the end of the runway where the pilot makes his landing approach; therefore, if this portion of the sky is free of clouds, you should append this remark to your observation. Check with your chief observer to find out the exact location of the middle marker relative to the ROS.

2-42. Other remarks describe a variety of observed features. Perhaps you might observe that the ceiling or sky condition at a distance from your station appears to be different. If you can find evidence that this is so, remark it in a fashion that tells exactly what you see. Here are samples of remarks you might use:

- CIG LWR OVR CITY—ceiling lower over city.
- MTNS OBSCD W—mountains obscured west.
- LWR CLDS W APCHG STN—lowe clouds west approaching station.
- MTN TOPS OBSCD NE-SE—mountain tops obscured northeast through southeast.

2-43. Also, you will see other stations frequently using the remarks THN SPOTS IOVC or CIG RGD. These two common remarks add a bit more detail to the meteorological picture as well as help air traffic. Though not strictly a cloud, when you observe *virga,* remark it and add the direction from station.

2-44. The presence of clouds (0/10) below other layers or in a clear sky condition is a good example of an operationally significant remark. This layer of clouds (0/10) cannot be entered in column 3 because it does not meet the criteria for a scattered layer. By making a remark such as CU W–N in column 13, you alert the forecaster to the presence and formation of a convective cloud. At coastal stations, perhaps the sighting of a distant layer (0/10) of stratus moving inland is significant. When a cloud code group is encoded in column 13 for layers not reported in column 3, an operationally significant remark is repetitious and need not be entered.

2-45. The final remarks in our discussion for sky condition are the obscuring phenomena remarks. Whenever the sky is partly obscured (−X), enter the type of phenomenon causing the obscuration and its amount in tenths. No remark is required for zero or ten tenths. For example, F2 indicates that 2/10 of the sky is obscured by fog or ground fog. Report only the letter that represents the form rather than the character of weather. For example, rainshowers are entered as "R" rather than "RW." When two elements contribute together to hide sky, combine them in a single amount, such as HF5.

2-46. When the obscuring phenomena are aloft rather than surface based, you must report the height and sky cover symbol with the type. For example, enter a scattered layer of smoke at 5,000 feet as K50⦶ (sky cover symbol from column 3). To enter this remark, you need to have a corresponding height and sky cover symbol in column 3. Whenever the obscuring phenomena aloft do not cover 0.1 of the sky at and below that layer, you cannot make this remark. You could, however, enter a remark similar to the 0/10 remark.

2-47. Following the sky condition entries on the AWS Form 10 is another important element of your observation—visibility. Before proceeding with the next section, refer to your workbook and answer the chapter review exercises for Section 2.

3. Visibility

3-1. Visibility, as well as ceiling height, aids in decisions involving air traffic control. For this reason, the observation of visibility must be timely, accurate, and representative. If the atmosphere were uniformly affected by obscuring elements, a single visual distance would be representative of each atmospheric condition. However, since fog, precipitation, and dust usually vary in thickness within short distances, the Air Force uses four types of visibility to present a representative picture—(1) prevailing visibility, (2) runway visibility, (3) sector visibility, and (4) runway visual range.

3-2. **Types of Visibility.** Each type of visibility fulfills a specific need of a representative observation. Prevailing and sector visibility refer mainly to meteorological visibility. Runway visibility and runway visual range fulfill visibility requirements along the active runway. These are not precise definitions but illustrate the specific purpose that each class of visibility fulfills. Now, let's examine each class separately.

3-3. *Prevailing visibility.* Prevailing visibility is the greatest distance that is common throughout half or more of the horizon circle that surrounds the station and at which selected objects can be seen and identified. Prevailing visibility does not have to occur in a continuous 180° arc. Various objects are selected as visibility markers to aid distance calculations in establishing the prevailing visibility.

3-4. Observing stations maintain a visibility chart or list to identify objects suitable for visual sighting. Size and color are used to determine the objects suitable for visual sighting. Unfortunately, objects that meet size and color requirements are not always present in every direction. When this is

TABLE 5
REPORTABLE VISIBILITY VALUES (MILES)

Increments of Separation (Miles)							
1/16	1/8		1/4	1/2	1		5
0	3/8	1 1/4	2	2 1/2	3	10	15
1/16	1/2	1 3/8	2 1/4	3	4	11	20
1/8	5/8	1 1/2	2 1/2		5	12	25
3/16	3/4	1 5/8			6	13	30
1/4	7/8	1 3/4			7	14	35
5/16	1	1 7/8			8	15	40
3/8	1 1/8	2			9		etc.

NOTES:
1. Statute miles at land stations; nautical miles on navy ships and ocean-station vessels. When the visibility is halfway between consecutive tabular values, select the lower value.
2. When the prevailing visibility is more than 7 miles and is also estimated to be more than twice the distance to the farthest marker visible, code the visibility as twice the distance to that marker, rounded to the nearest reportable value, and add a "+".
3. Suffix a "V," for variable, to the average of all observed values, whenever the prevailing visibility:
   a. is less than 3 miles, and
   b. rapidly increases or decreases by one or more tabular values during the period of observation.

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true, the station uses available objects. The type of visibility aid and the information it contains are left to the discretion of each station. Ideally, objects that can be readily identified are selected. Dark objects make the best day markers. At night the most suitable markers are unfocused lights of moderate intensity, not airway beacons whose light is focused and brilliant. To observe visibility accurately, you must be aware of several problems.

3-5. During night observation, for example, if you fail to permit your eyes to adapt to darkness, your observation can be in error. When ice or frozen precipitation accumulates on lights, it causes them to appear dimmer, even though there is no reduction in visibility. The transition periods during sunrise and sunset complicate visual sighting. Visibility appears to change at these times because the angle of the sun's light reduces the sharpness of object outline and relief. Lights used for night visibility also grow dim from lack of contrast. However, aside from the apparent changes in visibility due to optical effects, some real changes occur during these transition periods. For one thing, the visibility is reduced at dawn because of the concentration of moisture or haze trapped below a temperature inversion that formed during the night. Also, air pollutants (smoke, dust, industrial fallout) accumulate and reduce visibility at sunset when daytime heating effects subside and the lower air layers begin to settle. The observer faces other local and optical effects caused by humidity or cloudiness and snow-covered ground, and they affect visibility judgment.

3-6. Often you will notice that visibility markers stand out in bold relief and vivid color. No blurring or indistinctness exists. This indicates a visibility beyond the distance of the marker. When visibility appears greater than the most distant marker, you may estimate the visibility beyond. Do not estimate visibilities beyond whichever is greater—(a) 7 miles or (b) twice the distance to the most distant visibility marker.

3-7. Visibility markers are used to determine the distance you can see in statute (land) miles, but you cannot always report marker distances as prevailing visibility. A table of standard distances or reportable values provides uniform reporting distances for visibility regardless of marker distances. In table 5, Reportable Visibility Values, note the small increment between reportable values below 2 miles. Obviously, the more markers you have below 2 miles, the easier it is to judge visibility in bad weather. When a marker distance falls halfway between two reportable values, choose the lower value for reporting. Otherwise, select the value closest to your marker distance. Note 2 of table 5 explains the use of "+" visibilities. To use a "+," first you must estimate the visibility to be twice the distance to your most distant visible marker. Then if your estimation is also more than 7 miles, the + is justified. Your estimation, of course, is based on the sharpness and clarity of the markers.

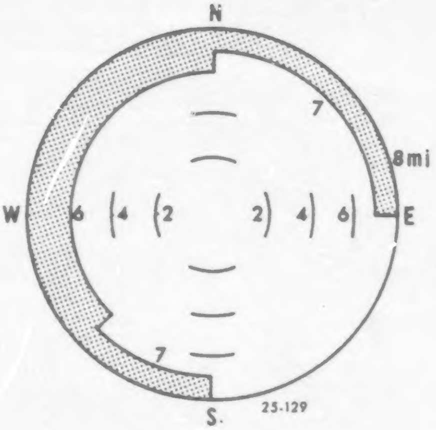


Figure 12. Sector visibility.

3-8. *Sector visibility.* Sector visibility actually becomes a part of determining prevailing visibility. Sector visibility points out a part of the horizon where the visibility is uniform. When observing visibility, divide the horizon circle into as few or as many parts as you need to separate the different sector visibilities. Figure 12 illustrates a horizon that is divided into four unequal sectors. Each sector presents uniform visibility within itself. For example, from north through east you can see 7 miles, east through south 8 miles, etc. These two sectors together give the prevailing visibility of 7 miles. The number of sectors you need depends upon the uniformity of the horizon visibility.

3-9. Sector visibility sometimes requires an explanation or remark. Refer to figure 13 and determine the prevailing visibility. The greatest distance

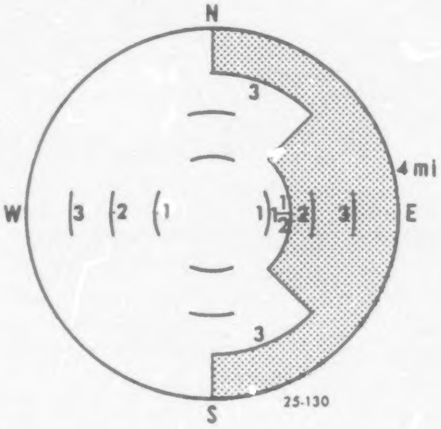


Figure 13. Sector visibility.

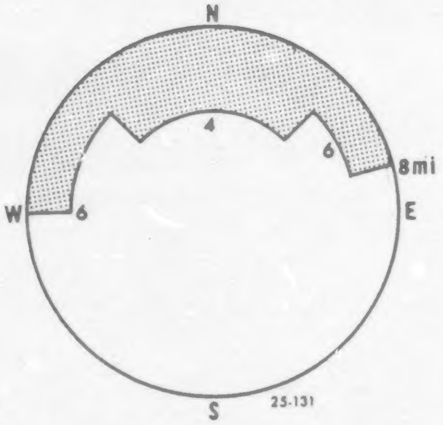


Figure 14. Sector visibility.

seen throughout the western half of the circle is 4 miles, the prevailing visibility. Imagine a pilot's surprise if he approaches the field from the east. The entire sector from northeast to southeast has a 1½ mile visibility. This sector is significant because of two criteria. First, sector visibility is reported when the sector visibility differs from the prevailing visibility, and second, when the sector has a visibility of less than 3 miles.

3-10. There is one more point that you need to consider concerning the significance of sector visibility. Suppose the sector visibility differs from prevailing visibility but is more than 3 miles. (See fig. 14.) Both criteria for reporting sector visibility are not met, but the difference is operationally significant. Operational significance is a legitimate reason for entering a remark on a sector visibility. Otherwise, with a prevailing visibility of 7 or more miles, no hint of an obstruction to vision is contained in the observation. Suppose there is a north-south active runway in figure 14. The 4-mile visibility in the north will go unnoticed unless you make an operationally significant remark to alert the pilot of the visibility in that sector. Therefore, when a sector visibility of 3 miles or more differs from the prevailing visibility, and you consider the difference operationally significant, enter a sector visibility remark on AWS Form 10.

3-11. *Runway visibility.* Two specific terms apply to the general topic "Runway Visibility"—runway visibility (RVV) and runway visual range (RVR). The major difference between the two is in reporting procedures. Before defining runway visibility in general, let's investigate why it is reported.

3-12. As you recall, prevailing visibility is based on the visual sighting of markers or unfocused lights of moderate intensity and gives a visual distance that is common to half of the horizon. Suppose the runway lies in a position where the visibility is quite different from the prevailing visibility. Even when sector visibility is reported, the sector where the runway is located might still be excluded. Runway visibility eliminates the possibility of this omission. Also, during a landing in poor visibility or at night, the pilot wants to know how far away he can see the high-intensity runway lights rather than the lights of moderate intensity that are used to obtain the prevailing visibility. In general, runway visibility represents the horizontal distance down the runway.

3-13. At stations equipped with high-intensity runway lights (HIRL), runway visibility is based on the current HIRL setting. You may derive the visibility value from the transmissometer reading or by visual sighting. The corrected transmissometer reading is converted to a runway visibility. Conversion tables provide day or night conversion with or without the HIRL operating. Table 6 combines excerpts from three separate conversion tables. When you must make a visual sighting, stand at the threshold edge of the in-use runway and count runway lights or known check points. Your station should have a chart for converting your count into reportable runway visibility values.

3-14. Report runway visibility when prevailing or runway visibility is 1 mile or less. Continue to report runway visibility in observations until the criteria above no longer exist. Your station takes observations of either runway visibility or runway visual range. Normally, runway visibility is not reported when runway visual range minimums are established at the station. However, an immediate operational need could make an exception to this normal practice.

3-15. *Runway visual range.* The second specific term applying to visibility along the runway is called runway visual range (RVR). Observation of RVR includes both the current runway light setting in use and the highest setting available for reporting purposes. Observe the current light setting as a 1-minute mean value and the highest setting as a 10-minute mean value. The 1-minute value is locally disseminated and the 10-minute values goes longline. RVR is the maximum distance seen down the runway from a point above center line at eye level to a pilot at touchdown.

3-16. Begin reporting RVR longline when the prevailing visibility reaches 1 mile or less or the highest RVR value for the runway in use is 6,000 feet or less. Also, special and local observations must be taken when certain established minima are reached.

3-17. As an observer, you should acquaint yourself with the RVR minima for all RVR runways. Make frequent observations of the readout when the visibility approaches the minima. Then when criteria are first met, you can make the proper local and longline dissemination.

TABLE 6
RUNWAY VISIBILITY CONVERSION

TABLE A3-9A (AF) TRANSMISSOMETER RUNWAY VISIBILITY CONVERSION TABLE
(500-Foot Baseline)

Day Corrected Transmissivity Value (Percent)						RVV (Statute Miles)
LS 3		LS 4		LS 5		
From	To	From	To	From	To	
.000	.085	.000	.023	----	----	1/8-
.086	.184	.024	.069	----	----	1/8
----	----	----	----	.000	.026	3/16-

1. 1/8- and 3/16- are referred to in voice transmissions as "less than one-eighth mile" and "less than three-sixteenths mile" and 1+ as "greater than one mile."

TABLE A3-9B (AF) TRANSMISSOMETER RUNWAY VISIBILITY CONVERSION TABLE
(500-Foot Baseline)

Night Corrected Transmissivity Value (Percent)						RVV (Statute Miles)
LS 3		LS 4		LS 5		
From	To	From	To	From	To	
.000	.012	----	----	----	----	3/16-
.013	.027	----	----	----	----	3/16
----	----	.000	.024	.000	.013	1/4-
.028	.071	.025	.042	[illegible]	[illegible]	[illegible]

1. 3/16- and 1/4- are referred to in voice transmissions as "less than three-sixteenths mile" and "less than one-quarter mile" and 1+ as "greater than one mile."

2. 1+ is used to report runway visibilities in excess of one mile when prevailing visibility is one mile or less.

3. Subtract background illumination from the transmission reading before entering this table with the transmissivity value.

TABLE A3-9C (AF) TRANSMISSOMETER RUNWAY VISIBILITY CONVERSION TABLE
(500-Foot Baseline)

Day Corrected Transmissivity Value (Percent)		Runway Visibility (Statute Miles)	Night Corrected Transmissivity Value (Percent)	
From	To		From	To
.000	.052	1/8-	----	----
.053	.172	1/8	----	----
----	----	3/16-	.000	.010
[illegible]	[illegible]	[illegible]	.011	[illegible]

4. Use this table only when HIRL are not installed or are inoperative.
5. Subtract background illumination from the transmission reading before entering this table with the transmissivity value.

3-18. **Visibility Entries and Remarks.** Visibility data falls into two classes—column 4 entries and column 13 (AWS Form 10) remarks. Column 4 is used for the prevailing visibility entry. At land stations, prevailing visibility is reported in statute miles, and you use the reportable values listed in table 5. The column 4 entry represents the prevailing ground level visibility taken at the observer's natural height from as many established observation points as necessary to view all markers. The only other entry in column 4 is made when there is a variable visibility. In this case, the letter "V" is affixed to the prevailing visibility entry to give an entry such as "1¼V." All other entries relating to prevailing visibility go in column 13.

3-19. *Variable visibility.* Note 3 of table 5 outlines rules for reporting rapidly changing prevailing visibility at the observation time. When you take a visual sighting on markers less than 3 miles away and the markers seem to appear and disappear alternately indicating an increasing and decreasing visibility, don't panic. Decide whether the visibility varies by one or more reportable values. At the same time, note all of your observed values, average them, and if your average is less than a reportable value of 3 miles, report the visibility as variable. This simply means that you place the average value in column 4 and affix a "V" to it. This average value, of course, represents the prevailing visibility that is common throughout half or more of the horizon circle.

3-20. The contraction "VSBY" identifies column 13 remarks that pertain to visibility. The column 13 variable visibility remark explains the range of the variable visibility. Remember that when visibility is variable, the prevailing visibility entry is an average. Therefore, the column 13 remark defines the high and low visibility observed. For example, a remark of "VSBY 1V2" means the visibility is varying between 1 and 2 miles. The reportable visibility values used in column 13 remarks are entered in accordance with table 5.

3-21 Occasionally, prevailing visibility is also taken by control tower personnel at a level other than the official point of observation. Regardless of this, column 4 always reflects the official point of observation visibility. However, a remark in column 13 can define the visibility from other levels when they are significant. Significant, in this case, means a visibility of 4 miles or less and different from the column 4 prevailing visibility. The remark identifies the different level visibility by a standard contraction, such as TWR VSBY 2 (tower visibility 2 miles).

3-22. *Sector remarks.* When sector visibility reporting requirements as previously discussed are met, the sector visibility remarks are entered in column 13. Sector remarks define direction and the visibility in the sector, such as VSBY E 1½, as shown in figure 13. Eight compass points are used to identify sector direction: N, NE, E, SE, S, SW, W, and NW. Intermediate directions (NNE) can also be used if necessary, although most directions can be described by the eight compass points. When more than one sector needs reporting, list the sectors in clockwise direction.

3-23. All the column 13 remarks relating to prevailing visibility fall in a lower priority than remarks for runway visibility. The high priority in order of entry given to runway visibility reveals its importance.

3-24. *Coding runway visibilities.* The standard contraction "RVV" identifies runway visibility, specifically. Routine transmission of RVV over weather teletype networks is not authorized. Therefore, the RVV entry is enclosed in parentheses to indicate local dissemination only. A typical RVV entry includes this listed information:

- Runway number (also includes runway designator "R" for right, "L" for left, or "C" for center).
- Visibility in reportable increments of statute miles, or "NO" for data required, but unavailable.

Sample RVV remarks appear as follows:

(R27LVV5/16)
(R09VV1/4)
(R17VV3/16–)
(R18VVNO)

Notice in each case the VV separates the actual visibility from other information. Also the value 3/16–indicates visibility less than 3/16 mile.

3-25. Entries for RVR include the same data as included with RVV, namely, runway number, designator and visibility. The reportable increments, however, are in hundreds of feet. For longline transmission, the 10-minute RVR entry follows the format R27CVR22 or perhaps R27VRNO. The 1-minute RVR entry differs from the 10-minute in several respects.

3-26. First, the 1M indicator flags the 1-minute data. Second, two 1-minute values are included in dissemination—one value for touchdown RVR, a second value for rollout RVR. Use a slant (/) to separate touchdown from rollout. Third, the 1-minute RVR is enclosed in parentheses because it receives local dissemination only. In other respects, the 1- and 10-minute RVR formats are identical. A sample 1-minute RVR entry is illustrated as 1MR27VR8/10. In the illustration, touchdown RVR equals 800 feet and rollout RVR equals 1,000 feet.

3-27. Briefly summarizing the role of visibility within the observing job, prevailing visibility supports the gathering of climatological data, forecasting, and to some extent air traffic operation. Prevailing visibility collection and reporting depends primarily upon visual sighting of specific markers. Through wise use of supporting remarks to describe variability and specific sectors, the prevailing visibility fulfills its part of the total visibility role. Runway visibility supports air traffic operation by filling in the gaps where prevailing visibility is weak. Before you begin the study of some of the weather elements that affect visibility, refer to the review exercises in the workbook and answer the items for Section 3.

4. Weather and Obstructions to Vision

4-1. To this point, you have seen how the primary users, pilots and forecasters, can use the sky condition and visibility entries to make decisions. Weather and obstruction-to-vision entries on Form 10 are not only a continuation of this discussion but are directly related to sky condition and visibility. The latter, visibility, is determined by the type of weather or obstruction to vision that is present. By knowing the type of phenomenon that is restricting visibility, the forecaster can make a better prediction of the future status of the visibility. The pilot uses this same information to determine what impact, if any, the weather phenomena will have on his operations. For instance, correctly reporting freezing precipitation is of utmost concern to the pilot. His aircraft could easily develop aerodynamic problems from icing because of this weather phenomenon.

4-2. Meteorologists use the type of weather and obstruction to vision in conjunction with other reports and data. By plotting this data on a workchart, they can correlate the weather phenomena with radar information, pilot reports, and other surface weather observations. This type of forecasting service which the duty forecaster provides at your station and which the forecast centers provide, enables *military* and *civilian* agencies alike to receive *prompt notification* of diminishing or improving weather conditions.

4-3. Volume 1 of this course provided the necessary knowledge of the meteorological processes that produce weather and obstructions to vision. This section discusses more specifically the way to recognize each weather phenomenon and the way to correctly encode it in your surface weather observation.

4-4. **Storm Phenomena.** Though the term "weather" is often used in a broad sense, in observing circles it refers specifically to atmospheric phenomena that are the basis for the entry in column 5 of AWS Form 10. Hurricanes usually generate in the Atlantic Ocean, and tornadoes are a phenomenon that occurs more often in the United States than in the rest of the world.

4-5. *Hurricane.* A hurricane is a special weather phenomenon distinguished from the others by its comparative size. This storm encompasses so vast an area that its presence is obvious and, therefore, is not reported as such on the Form 10. All the clouds, precipitation, and winds associated with hurricanes are reportable as individual elements.

4-6. *Tornado, funnel cloud, and waterspout.* Tornadoes, waterspouts, and funnel clouds are weather phenomena that occur in areas where intense thunderstorm activity is possible. However, they may or may not occur in conjunction with thunderstorms. In any case, they stem from the same cloud form—the cumulonimbus. This cloud spawns the frontal and airmass thunderstorms (discussed in Volume 1), which are usually characterized by thunder, lightning, strong wind gusts, heavy rain showers, and sometimes hail. Under certain conditions, the potentially destructive energy produced within a cumulonimbus mass is released in the form of a whirling vortex beneath the cloud. When the whirling vortex does not reach the ground, it is called a *funnel cloud;* when the vortex, with its low pressure and tremendous winds, touches the ground, it is called a *tornado.* When the vortex descends to the surface over water rather than over land, it is called a *water spout.*

4-7. The distinguishing feature of a tornado, funnel cloud, or waterspout is a funnel-shaped appendage that hangs from the base of the cloud. Sometimes thunderstorms are in progress at the time a funnel descends, and precipitation prevents easy detection of the funnel cloud or tornado. Depending on the distance from the point of observation, funnel cloud or tornado identification ranges from the obvious to the doubtful. For example, the ragged appearance of a cumulus fractus cloud associated with bad weather may suggest a funnel-shaped appendage. Since these cloud elements usually change rapidly, close observation for a short time usually resolves the question of whether or not a funnel actually exists. Your judgment, based on the best information available, is the key ingredient.

4-8. *Thunderstorm.* Thunderstorm activity, though not as serious as tornadoes, presents many hazards to flight operations. For observing purposes, a thunderstorm is present when:

a. Thunder has been heard within the last 15 minutes.

b. Overhead lightning or hail was observed within the past 15 minutes and the local noise level prevents you from hearing thunder.

4-9. A thunderstorm entered on Form 10 is classified as an ordinary thunderstorm (T) or a severe thunderstorm (T+). This determination is made over a 15-minute interval according to these guidelines:

T Thunderstorm—wind gusts less than 50 knots and hail, if any, less than ¾ inch in diameter.

T+ Severe thunderstorm—wind gusts of 50 knots or greater, hailstones ¾ inch or longer in diameter.

4-10. Once you have identified the presence and type of thunderstorm, you need to determine the following information for entry in column 13:

a. The location of the storm(s) with respect to the station.

b. The direction toward which the storm(s) is moving: omit if unknown.

c. Whether lightning is occurring from cloud to cloud, cloud to ground, cloud to air, or within the clouds.

4-11. **Precipitation Forms.** Precipitation falls in many forms. Generally speaking the various types are classified into three main categories:

- Liquid (rain and drizzle)
- Freezing
- Solid

4-12. *Liquid precipitation (rain and drizzle).* Rain and drizzle are the only two forms of liquid precipitation. Rain is distinguished from drizzle by the size of the water droplet (particle) and the spacing between droplets. Rain droplets have a diameter usually greater than .02 inch, whereas drizzle has a droplet size less than .02 inch. The drizzle droplets are very close to each other and appear to float with the air currents. Drizzle usually falls from low stratus clouds and is frequently accompanied by low visibility and fog.

4-13. *Freezing precipitation.* Freezing precipitation is liquid precipitation that falls and freezes upon impact with the ground or objects on the ground. Usually, freezing precipitation is caused by supercooled water particles, but it may occur when the surface is cold enough to freeze water particles that are near freezing. When water particles do freeze upon impact with objects on the ground or with the ground itself, classify the precipitation as either *freezing drizzle* or *freezing rain.* When precipitation is already in the solid state, it is classified according to its *appearance* and *character.*

4-14. *Solid precipitation.* For observing purposes, solid precipitation is classified into the following precipitation forms:

- Ice pellets
- Hail
- Snow
- Snow pellets
- Snow grains
- Ice crystals

4-15. Ice pellets. Ice pellets are either transparent or translucent particles of ice which are round or irregular in shape (rarely conical) and have a diameter of 0.2 inch or less. Ice pellets are formed by two different processes. If *continuous* precipitation (such as rain or melted snowflakes) freezes, the result is a transparent ice pellet (formerly called sleet). Ice pellets are also classified as such when snow grains become encased in a thin layer of ice. This occurs when a snow pellet begins to melt and refreezes, or it may also occur when snow pellets come in contact with water droplets while falling. In this case the water freezes, producing a thin layer of ice around the snow pellet. Ice pellets usually rebound when striking hard ground and make a sound on impact.

4-16. Hail. Hail is distinguished from the other solid precipitation by its irregular shape and generally large size. Hail falls almost exclusively from strong convective clouds (cumulonimbus) which are usually accompanied by thunder. Some hailstones consist of alternately opaque (snowflakes) and clear layers, which are formed by the strong up and down drafts within the cloud. On occasion, hailstones coalesce (a uniting of elements) and fall together in lumps. When hail falls at the station, you must determine the size of the largest hailstone that is readily available. Hail seldom occurs when surface temperatures are near or below freezing.

4-17. Snow. Snow is solid precipitation in the form of branches, often hexagonal (six-pointed). Snow crystals must be formed beyond the crystalline stage (earliest stage of development). Since there are numerous shapes and sizes of snowflakes and snow crystals, the best guide to use in determining snow is to look for "branching" in the snowflake. If no branching is evident, it is another form of solid precipitation.

4-18. Snow pellets. Snow pellets are white, opaque grains of ice, resembling snow crystals. The primary difference between snow pellets and snow is the spherical or sometimes conical form of the snow pellets. Snow pellets are brittle and compress easily. When they strike hard surfaces, they bounce and often break up. When conditions are right, snow pellets serve as the nuclei for hail development. Snow pellets form almost exclusively in convective clouds which produce showery precipitation.

4-19. Snow grains. Snow grains are very small, white, opaque grains of ice, similar in structure to snow crystals. The primary difference is the smallness of each element and the fairly flat or elongated shape of the snow grains in comparison to snow crystals (snow). They do not burst or shatter when they strike hard surfaces. Snow grains usually fall in small quantities mostly from stratus clouds.

4-20. Ice crystals. Ice crystals are unbranched, in the form of needles, columns, or plates. They are often so tiny that they seem almost to be suspended in the air. Ice crystals fall from a cloud or from a clear sky. They are usually transparent and often pyramidal in form. When the ice crystal development is clear-cut and prismlike, they often exhibit optical effects, such as halo phenomena and scintillation (sparking or twinkling) in sunlight or beams of lights. This type of solid precipitation is very rare and is seldom observed at intensities other than very light. The key identifying features of ice crystals are the slow rate of fall, the smallness of size, and the optical effects they produce. Once you are familiar with the identifying features of each type of precipitation, you need to be able to determine the character of each precipitation form.

4-21. **Character of Precipitation.** Knowing the type of precipitation that is associated with low ceilings and visibilities is undoubtedly of great benefit to both the pilot and forecaster. This information is made even more meaningful when the character of the precipitation is added. The pilot is very interested in knowing the presence of rainshowers rather than rain, because rainshowers tell him to expect a greater fluctuation in visibility as he lands or takes off from the airbase. The decision of whether the precipitation is showery or continuous is determined by the observer's judgment based on experience and established guidelines. Precipitation character is based upon established criteria. The character of precipitation is divided into four categories:

- Continuous
- Intermittent
- Showery
- Combinations

4-22. *Continuous.* Continuous precipitation increases or decreases gradually in intensity, if at all. Precipitation of this character is usually associated with stratiform cloud types such as altostratus, nimbostratus, and stratus.

4-23. *Intermittent.* Intermittent precipitation also increases or decreases gradually in intensity. However, to be classified as intermittent, the precipitation must stop and start at least once within the hour preceding the observation. This character of precipitation is used with precipitation types not classified as showery and is indicated by a remark in column 13 (for example, INTMTR–).

4-24. *Showery.* Showery precipitation changes intensity rapidly, or the shower begins and ends abruptly. Swelling cumulus and cumulonimbus clouds produce showery precipitation. When showers have ended at the observation site (ROS) but are still in progress near the station, this can be indicated by entering an appropriate remark on Form 10.

4-25. *Combinations.* Combinations of showers and continuous or intermittent precipitation can occur at the same time. This is not unusual with frontal passages. Once the character of liquid, freezing, or solid precipitation is determined, the intensity of the precipitation form is determined and the appropriate symbol is added to the observation.

4-26. **Intensity of Precipitation.** With the exception of hail and ice crystals, each precipitation form is suffixed with an intensity symbol. The symbol is "– –" for very light intensity, "–" for light intensity, an omission (no symbol) for moderate intensity, and "+" for heavy intensity.

4-27. Determine the intensity of precipitation from established standards, such as FMH–1. It provides tables which can be used to determine intensities. Tables 7, 8, 9, and 10 are reproductions

TABLE 7

INTENSITY OF PRECIPITATION (OTHER THAN DRIZZLE) ON RATE-OF-FALL BASIS

Very Light	Scattered drops or flakes that do not completely wet or cover an exposed surface, regardless of duration.
Light	Trace to 0.10 inch per hour; maximum 0.01 inch in 6 minutes.
Moderate	0.11 inch to 0.30 inch per hour; more than 0.01 inch to 0.03 inch in 6 minutes.
Heavy	More than 0.30 inch per hour; more than 0.03 inch in 6 minutes.

TABLE 8
INTENSITY OF DRIZZLE ON RATE-OF-FALL BASIS

Very light	Scattered drops that do not completely wet an exposed surface, regardless of duration.
Light	Trace to 0.01 inch per hour.
Moderate	More than 0.01 inch to 0.02 inch per hour.
Heavy	More than 0.02 inch per hour.

Note: When precipitation equals or exceeds 0.04 inch per hour, the precipitation is usually rain.

of these tables. Note that tables 7 and 9 are used for precipitation other than drizzle, and tables 8 and 10 are used for drizzle. Tables 7 and 10 are also used to determine the intensity of snowfall. To improve your judgment in determining intensity of precipitation, observe the precipitation over a period of time. Frequently, the total precipitation (water equivalent) for the day is not supported by the intensities that the observer reports for precipitation during the day. For example, suppose an

TABLE 9
GUIDES FOR APPROXIMATING INTENSITY OF RAIN

Very light	Scattered drops that do not completely wet an exposed surface, regardless of duration.
Light	Individual drops are easily identifiable; spray observed over pavements, roofs, etc., is slight; puddles form very slowly; over 2 minutes may be required to wet pavements and similarly dry surfaces; sound on roofs ranges from slow pattering to gentle swishing; steady small streams may flow in gutters and downspouts.
Moderate	Individual drops are not clearly identifiable; spray is observable just above pavements and other hard surfaces, puddles form rapidly; downspouts on buildings run ¼ to ½ full; sound on roofs ranges from swishing to gentle roar.
Heavy	Rain seemingly falls in sheets; individual drops are not identifiable; heavy spray to height of several inches is observable over hard surfaces; downspouts run more than ½ full; visibility is greatly reduced; sound on roofs resembles roll of drums or distinct roar.

TABLE 10

INTENSITY OF DRIZZLE AND SNOW WITH VISIBILITY AS CRITERION

Very light - - - -	Scattered droplets or flakes that do not completely cover or wet an exposed surface, regardless of duration.
Light - - - - - - -	Visibility 5/8 statute mile or more.
Moderate - - - - -	Visibility less than 5/8 statute miles but not less than 5/16 statute mile.
Heavy - - - - - - -	Visibility less than 5/16 statute mile.

observer carries very light continuous precipitation interspersed with short periods of light precipitation for a 6-hour period, but his measurement at the end of the 6-hour period exceeds 1 inch. Since an intensity of light for the entire 6-hour period should yield less than 1 inch (based upon table 7), the intensities as carried by this observer are too light. Remember that precipitation that is very light in intensity does not completely wet an exposed surface, regardless of its duration. A check of precipitation amounts for a 6-hour period and for the day is a good indication of whether or not you are entering the correct intensities.

4-28. Whenever more than one form of precipitation is occurring simultaneously, tables 7 and 10 provide the guide for determining intensity, provided that you give proper consideration to the relative proportion of each type of precipitation. If your station *does not* have a recording or totalizing gage, but has a standard rain gage, use:

a. Table 10 for drizzle or snow not occurring simultaneously.

b. Table 9 for rain.

c. Table 8 when drizzle occurs with obstructions to vision, such as fog.

d. Table 7 and your experience when snow occurs with obstructions to vision. Obstructions to vision, as well as "weather," are also of great concern to the pilot and forecaster.

4-29. **Obstructions to Vision.** This category includes all other types of atmospheric phenomena not considered "weather." Since visibility is affected by obstruction-to-vision phenomena, the forecaster studies reports of the obstructions to vision present at his station as well as reports from surrounding stations. This data and his knowledge of the meteorological factors that influence changes to the obstructions to vision are important aids in flight operations and scheduling. Obstructions to vision are not entered in column 5 of AWS Form 10 unless they restrict the visibility to *less* than *7 miles*. However, those that you think are operationally significant should be entered in the Remarks section. In fact, these remarks are encouraged. Remember that when obstructions to vision cover 0.1 or more of the sky, they are considered as sky coverage (−X or X). All obstructions to vision are classified as either a hydrometeor or lithometeor.

4-30. *Hydrometeors.* A hydrometeor is an atmospheric phenomenon that consists of liquid or solid water particles. When these particles are falling, they are called precipitation. When they are suspended in the atmosphere, they are called obstructions to vision. For observing purposes, there are five hydrometeors that are considered obstructions to vision:

- Fog.
- Ground fog.
- Blowing snow.
- Ice fog.
- Blowing spray.

4-31. Fog is a suspension of small water droplets in the air, reducing horizontal visibility at the earth's surface. Fog is distinguished from haze and other obstructions to vision by its dampness and grey appearance. Usually fog does not form or exist when the difference between the temperature and dewpoint is greater than 4 Fahrenheit degrees; however, it should be reported whenever it is observed. When temperatures are below freezing, the difference may exceed 4 Fahrenheit degrees. Heavy fog sometimes produces rime or glaze on cold, exposed objects. For classification purposes, the difference between fog and ground fog is that fog either extends to the base of the clouds or hides at least 0.6 of the sky if it does not reach to the base of the clouds.

4-32. Ground fog, on the other hand *does not* reach the base of the clouds and covers less than 0.6 of the sky. Therefore, ground fog appears the same as fog but differs from fog by the amount of sky it covers and because it does not reach the base of the clouds.

4-33. Blowing snow exists when the wind blows snow to moderate heights. Blowing snow is closely related to *drifting snow;* the main difference is that *blowing snow* restricts visibility at eye level (6 feet) to less than 7 miles and drifting snow does not. Therefore, drifting snow is *not entered* in column 5 of AWS Form 10.

4-34. Ice fog is a rare form of fog, because it usually forms at temperatures below −20° F. Ice fog does not produce rime or glaze on cold objects. It consists of elements very similar to ice crystals except that ice fog particles are suspended in the atmosphere. Ice fog produces optical effects that are similar to those produced by ice crystals, such as halo phenomena, luminous vertical columns, or scintillating effect. Ice fog can form at temperature and dewpoint differences of 8 Fahrenheit degrees or more.

TABLE 11
SYMBOLS FOR WEATHER, COLUMN 5

Tornado, waterspout, and funnel cloud are always written out in full.

Symbol	Type of Weather	Symbol	Type of Weather
T+	Severe Thunderstorm	IPW	Ice Pellet Showers
T	Thunderstorm	S	Snow
R	Rain	SW	Snow Showers
RW	Rainshowers	SP	Snow Pellets
L	Drizzle	SG	Snow Grains
ZR	Freezing Rain	IC	Ice Crystals
ZL	Freezing Drizzle	A	Hail
IP	Ice Pellets		

Suffix a "+" to precipitation symbol to indicate heavy intensity, a "-" for light intensity, and "- -" for very light intensity. The absence of an intensity symbol indicates moderate, except that no suffix is attached with "A" for hail or "IC" for ice crystals, regardless of intensity.

TABLE 12

SYMBOLS FOR OBSTRUCTIONS TO VISION, COLUMN 5

Symbol	Type of Weather	Symbol	Type of Weather
F	Fog	IF	Ice Fog
GF	Ground Fog	H	Haze
BS	Blowing Snow	K	Smoke
BN	Blowing Sand	D	Dust
BD	Blowing Dust	BY	Blowing Spray

Note: Intensity is not indicated for obstructions to vision, rather obstructions are reported in their order of predominance.

4-35. Blowing spray is reported only at sea stations or stations near large bodies of water. To be reported, the spray, which is water droplets that are torn from the water by the wind, must restrict the horizontal visibility to less than 7 miles. Unless you are assigned to a station near a large body of water, you will never have to report this obstruction to vision in your observation. All obstructions to vision are not caused by hydrometeors; some are caused by impurities in the atmosphere and are called lithometeors.

4-36. *Lithometeors.* All obstructions to vision that do not have a water composition (hydrometeor) and are not classified as "weather" are called lithometeors. They are classified into five separate types as follows:

- Dust
- Blowing dust
- Blowing sand
- Haze
- Smoke

4-37. Dust is finely divided earthy matter that is uniformly distributed in the atmosphere. You can distinguish it from other lithometeors by the tannish or greyish hue that it imparts to distant objects. When dust is present, the *sun's disk is pale and colorless,* and a yellow tinge prevails throughout the atmosphere.

4-38. Blowing dust is dust that the wind picks up from the surface and blows about in clouds or sheets. To be classified as blowing dust, it must restrict the visibility to less than 7 miles. Blowing dust sometimes obscures the entire sky.

4-39. Blowing sand is reported when the wind picks up sand from the surface and blows it about in clouds or sheets. Blowing sand consists of larger particles than blowing dust. Because of its heavier composition, the wind does not carry blowing sand as high or as far as it carries blowing dust. When the winds are very strong, blowing sand easily restricts the visibility to less than ½ mile.

4-40. Haze is suspended small, dry particles, such as salt, dust, or pollen, that are invisible to the naked eye. In spite of the fineness of haze particles, haze restricts visibility. Over the landscape, haze resembles a uniform veil that subdues the natural colors, such as green trees along the horizon. When viewed against a dark background, such as a mountain, haze produces a bluish tinge. It causes a dirty yellow or orange tinge against a bright background, such as the sun, clouds on the horizon, or snow-capped mountain peaks. When the sun is well above the horizon, its light sometimes has a peculiar silvery tinge because of haze. These color effects distinguish haze from light fog, even when the thickness of the haze approaches that of light fog. Haze and smoke often occur together; therefore, how is smoke different? How can you distinguish between the two?

4-41. Smoke is a very common obstruction to vision near large cities and industrial areas. It consists of fine ash particles produced by combustion. When it is viewed through smoke, the *disk of the sun or a sunset appears very red*. When the sun is above the horizon, it may have an orange tinge. Smoke at a distance or in a layer is usually light greyish or bluish. When smoke is in heavier layers, it assumes the darker coloration associated with newly formed smoke and is easily identified. When you know the weather and obstructions to vision that are reported, you must consider the correct method of entering them on AWS Form 10.

4-42. **Order of Entry for Weather and Obstructions to Vision** Whenever weather or obstruction to vision are present at the time of an observation, you must enter the appropriate weather symbol in column 5 of Form 10. The correct order of entry should be:

a. Tornado, funnel cloud, or waterspout.

b. Thunderstorm.

c. Liquid precipitation in order of decreasing intensity.

d. Freezing precipitation in order of decreasing intensity.

e. Solid precipitation in order of decreasing intensity.

f. Obstructions to vision in order of decreasing predominance. if you can tell which is predominant.

Table 11 shows the weather symbols that are used in column 5, and table 12 shows the symbols for obstructions to vision. Remember, to enter obstructions to vision, you must have a prevailing visibility (column 4 entry) of *less than 7 miles*.

4-43. As indicated in table 11, tornado, waterspout, or funnel cloud is always spelled out in full. This permits ready identification of these severe weather phenomena. If there is not enough space in column 5 for a one-line entry, use as many lines in column 5 as necessary and start subsequent observations on the next line. There are several weather and obstruction-to-vision entries that require remarks in column 13 of AWS Form 10. These are explained in the following paragraphs.

4-44. **Entries and Remarks for Weather (Column 13).** Significant remarks for weather and obstructions to vision provide added information for the entires in column 5. Some of these remarks provide additional information on severe weather types such as tornadoes, thunderstorms, and hail, to mention a few. These weather types present a constant threat to the public as well as to flying operations. Your remarks on severe weather alert pilots to its location, the direction it is moving, and other information that adds to the basic remark. Though this is a discussion of only significant remarks, you are encouraged to enter any remark that you think is operational.

4-45. The following guidelines apply to *all column 13 remarks* as well as those for weather and obstructions to vision.

a. Use accepted weather contractions whenever possible.

b. Spell out remarks that may be misinterpreted for other data ("SW"—Is this southwest or snow showers?).

c. Enter directions of phenomena, using the 16 points of the compass (N, NE, NNE, etc.).

d. Enter a dash between the directions when the phenomenon extends from one point of the horizon to another (NE–SE or N–NE).

e. Enter additional direction references in a clockwise direction when the phenomenon exceeds a 90° portion of the horizon circle (NW–NE–E or N–E–SSE).

f. Enter distances to phenomena in nautical miles when known and appropriate.

g. Enter all time references in GMT.

4-46. *Tornado*. Whenever a tornado, funnel cloud, or waterspout is *sighted by station personnel* enter the type, beginning time, direction from station, and direction toward which it is moving. Also enter the peak wind on each *record observation* while tornadic activity is in progress. (Peak wind format—direction, speed, separated by a slant, and the time of occurrence in minutes past the hour.) The following are three examples:

TORNADO B53 W MOVG NE PK WND 27/85 58
FUNNEL CLOUD B52 NW MOVG NE PK WND 27/43 55
WATERSPOUT B51 N MOVG NE PK WND 29/35 54

4-47. When the phenomenon *ends* or *disappears from sight*, enter type, time of ending, direction of movement, and peak wind. (Peak wind definition same as entered for beginning format.) Examples are shown as follows:

TORNADO E54 MOVD NE PK WND 27/80 35.
FUNNEL CLOUD E52 MOVD NE PK WND 28/45 40
WATERSPOUT E56 MOVD E PK WND 30/37 51

4-48. When a special observation for beginning and/or ending of tornadic activity is not transmitted longline, enter the beginning and/or ending time in each subsequent special, record, or record special observation until it is transmitted longline.

4-49. When tornadic activity (tornado, funnel cloud, waterspout) is reported by the public as having occurred in the past 6 hours and has not been observed at the station or previously reported by another source, you should report it in column 13 of AWS Form 10. Enter source, or if unknown, enter "unconfirmed," location, direction of movement, and time it was observed in hours and minutes. The following are two examples:

STATE POLICE TORNADO 8W FWH MVG E 1930
UNCONFIRMED FUNNEL CLOUD 20W CLL MVG E 1920

These sightings are usually made at locations other than your immediate station; therefore, include the nearest known reference point, which may be your station, to pinpoint the location of the phenomenon. In the preceding examples, 8W FWH indicates 8 miles west of Fort Worth and 20W CLL indicates 20 miles west of College Station, Texas. Thunderstorm activity is another form of severe weather for which significant remarks should be entered whenever observed.

4-50. *Thunderstorm.* Whenever a thunderstorm is in progress, and when it ends, or disappears, a significant remark is required. For a thunderstorm in progress, enter the type (T or T+), time of beginning, direction from station, and if known, the direction of movement for each center of activity. Also enter the peak wind on each *record observation* while thunderstorm activity is in progress. Some examples are:

Transmitted Special Observation: T B26 NW MOVG SE
Transmitted Record Observation: T NW MOVG SE PK WND 30/45 35

4-51. In these examples, the thunderstorm remark without the beginning time indicates that the beginning time was transmitted over the longline circuit, and no starting time was needed. The rule for this is: When a special observation for beginning and/or ending of thunderstorm activity is not transmitted longline, enter the beginning and/or ending time in each subsequent special, record, or record special observation until it is transmitted longline.

4-52. When the phenomenon *ends* or *disappears from sight,* enter type (T or T+), time of ending, and direction of movement for each center of activity. These are examples:

Record Observation: T+ E54 MOVD E PK WND 30/45 37
Record Observation: TB3/E49 MOVD E PD WND 32/38 40

4-53. The above remarks are typical examples of thunderstorm ending remarks. The first example shows a thunderstorm that has lasted more than hour, or the beginning time was transmitted on a previous special observation. The second example shows a thunderstorm of short duration that began and ended within the same hour, and the beginning time *did not* get a transmitted via longline. Lightning is usually visible with most thunderstorm activity and should also be reported.

4-54. *Lightning (LTG).* Lightning, though not considered as weather, is associated with thunderstorms. Therefore, remarks about the frequency and type of lightning provide useful data to the forecaster. The frequency of discharges provides the forecaster with an indication of thunderstorm intensity, and the type of lightning alerts the forecaster to other features of the storm system. For example, lightning discharges from one cloud to another reveal the presence of multicell rather than single-cell activity. Lightning from cloud to ground indicates that the cloud has begun to precipitate and the associated cumulonimbus cloud is probably in the advanced stage of development.

4-55. Lightning remarks are made with or without the presence of audible thunder. When a thunderstorm is present, lightning remarks are placed after the associated thunderstorm remark in column 13. Each lightning remark should contain the *frequency, type,* and *direction* from the station. The following contractions are used for lightning remarks:

Frequency
OCNL—Occasional
FQT —Frequent

TYPE
IC —In-cloud
CC —Cloud to cloud
CG —Cloud to ground
CA —Cloud to air

The following examples show how these contractions are used as remarks:

OCNL LTGIC W
FQT LTGCCCG N–E
FQT LTGIC W–NW OCNL LTGCC E

Whenever thunderstorms and lightning are present, *hail* is very possible, which requires a remark and is the next topic of discussion.

4-56. *Hail (A).* Hail is another severe weather phenomenon that is associated with thunderstorm activity. Large hail can cause extensive damage to aircraft structures. Therefore, the forecaster carefully scans airways reports for hail activity in the area. When you observe hail at your station, you should include a remark with your observation.

4-57. Hail is entered in column 13 *usually* following your remarks concerning lightning. Include the time of beginning and/or ending and diameter in inches of the *largest* hailstone. Hail is also a requirement for peak wind entries; however, the case of having hail without a thunderstorm in progress would indeed be a rare phenomenon. So for all practical purposes you have already determined the requirement for peak wind from the thunderstorm criteria. The following are examples of hail entry remarks:

AB35 HLSTO 1 1/4
AB35E47 HLSTO 2
AE47 HLSTO 1

The first example shows when the hail began (B35). The second example shows both the beginning and ending time since the beginning time has not previously been transmitted. The third shows only when the hail ended because the beginning time has previously been transmitted.

4-58. Knowing which remarks to enter in column 13 for hail, tornadoes, thunderstorms, and lightning greatly increases the usefulness of your observation. During periods of severe weather, all the elements of your observation change rapidly as the severe weather passes your station. If you have to research each remark to see how to enter it, the quality of your work undoubtedly suffers and your observation may be outdated before it is transmitted. You can avoid this situation by *being prepared* for these sudden changes of weather. Prepare yourself by *obtaining a briefing* from the forecaster before your shift starts and by *reviewing policies for weather phenomena* that are peculiar to your location and the season. In addition to the significant remarks concerning severe weather phenomena, there are other remarks which lend meteorlogical significance to your observation. Some of these are discussed in the following paragraphs.

4-59. *Other significant remarks.* Tabulated below are observed elements and conditions that require remarks, the guidelines for their entry, and some examples of typical entries.

Observed	*Guidelines for Reporting*	*Typical Entry*
Intermittent precipitation	Enter character and intensity for all types of precipitation *classified as intermittent*, occurring at observation time or within past 15 minutes.	INTMT R– (intermittent light rain)
Showery precipitation (not reported in column 5)	Enter character and intensity for *all* types of *showery* precipitation occurring at observation time or within past 15 minutes. However, a remark is usually entered only if the precipitation has stopped and recommencement within 15 minutes appears probable.	OCNL RW– (occasional light rain shower)
Wet snow	Self-explanatory.	WET SNOW
Increase in snow depth	Average snow depth increases by 1 inch or more during past hour.	SNOINCR 2
Variation of precipitation intensity	When the intensity of *continuous* precipitation varies.	R–OCNLY R (light rain occasionally moderate)
Precipitation at a distance but not at station	Enter form and intensity of precipitation if known and direction with respect to station. Use a "U" following precipitation symbols to indicate unknown intensity. Use authorized abreviations or plain language as needed.	RU OVR RDG N (rain of unknown intensity over ridge to north) RWU W (rain showers of unknown intensity west)
Fog dissipating or increasing	Self-explanatory.	F DISIPTG (or F INCRG)
Smoke drifting over field	Self-explanatory.	K DRFTG OVR FLD
Shallow ground fog	When the ground fog depth is less than 6 feet deep. Enter shallow ground fog depth in feet.	SHLW GFDEP 4
Drifting snow	When snow is drifting and does not restrict the visibility at eye level (6 feet above the surface). Omit if blowing snow (BS) is reported.	DRFTG OVR FLD
Dust devils	Enter "dust devils" followed by direction from station.	DUST DEVILS SW
Obscuring phenomena at a distance from and not at the station.	Enter type, description and direction from the station	F BANK N–E–S

4-60. Different airmasses and weather systems create situations that require an entry of operationally significant remarks in column 13. As you gain experience as an observer, you will increase your proficiency in entering remarks that add to the usefulness of your observation. To this point, you have seen the way to record sky condition data, visibility, weather, and obstruction-to-vision data. Together, these data provide the basic information necessary to make operational decisions. However, to make these entries more meaningful, they must be combined with the other elements of the observation to provide a complete weather summary which serves the needs of all interested parties.

4-61. At this point, take a break and refer to the chapter review exercises in your workbook and answer the items for Section 4.

5. Pressure

5-1. The first accurate pressure measuring device was invented in 1643 by an Italian scientist named Torricelli. Torricelli found that when he inverted a long tube filled with mercury so that the open end of the tube was immersed in a dish of mercury, only a small amount of mercury would run out of the tube. Sufficient mercury would remain in the tube to form a column approximately 30 inches high. This elementary device, modified and refined over the years, became the mercurial barometer that we know today.

5-2. Other pressure measuring devices such as the aneroid barometer, have come into being since Torricelli's era. Most modern barometers accurately measure atmospheric pressure within 0.005 inch of mercury. The mercurial barometer measures pressure to the nearest 0.001 inch of mercury. Such accurate pressure readings are essential to the continuing study of the atmosphere. The prime consideration for any major chart analysis that the forecaster makes is the distribution of atmospheric pressure. The forecaster knows that the intensification or weakening of low-pressure areas usually causes pronounced changes in the weather.

5-3. **Types of Pressure Data.** This discussion is based on *three main pressure concepts.* These concepts are sea-level pressure, altimeter setting, and station pressure. First, the forecaster needs a pressure value that he can use in the analysis of weather systems and the prognosis of these weather systems (sea-level pressure). Second, the pilot must have a pressure value that provides him with a reliable indication of his inflight altitude above sea level (altimeter setting). Third, you must determine a basic pressure value that is used for the computation of the other two operational pressure values (station pressure).

5-4. Your responsibility is to derive and record this information as part of your observation on AWS Form 10. This section discusses the observing functions necessary to make these pressure entries. Barometric equipment is discussed in Volume 1, Chapter 3, Weather Station Equipment.

5-5. Atmospheric pressure is defined as *the pressure exerted by a column of air, of unit area, extended vertically from the reference surface to the top of the atmosphere.* Figure 15 illustrates a column of air that is exerting pressure at a given location on the earth surface. The illustration shows the influence that this air column has on a column of mercury. This measurement of atmospheric pressure is the basis for all pressure values regardless of your location, the height above sea level, or the type of pressure measuring equipment.

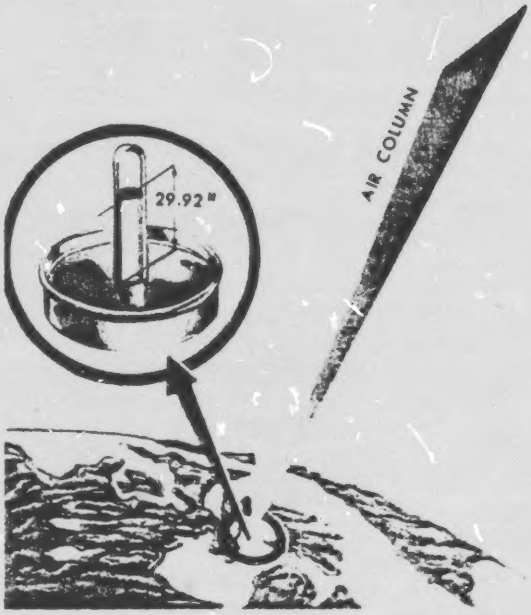


Figure 15. Column of air and column of mercury.

5-6. Atmospheric pressure is measured most often in millibars or inches of mercury. In AWS, sea-level pressure data is reported in millibars, but the pressure readings are taken in inches of mercury. This height in inches of mercury should correspond exactly to the weight of the column of air as illustrated in figure 15.

5-7. Atmospheric pressure readings at AWS detachments are obtained from aneroid barometers, microbarographs, and mercurial barometers. Each of these instruments has advantages and disadvantages; and an order or priority is established for their use.

a. The *aneroid barometer* has first priority for determining pressure readings, if considered accurate.

b. The *microbarograph* is used whenever the aneroid barometer is judged inaccurate.

c. The *mercurial barometer* is used only to determine the accuracy of the aneroid or to establish corrections for the microbarograph when the aneroid is judged inaccurate. These weather instruments are discussed in Volume 1, Chapter 3, Weather Station Equipment. At present we will consider the actual data derived from atmospheric pressure readings.

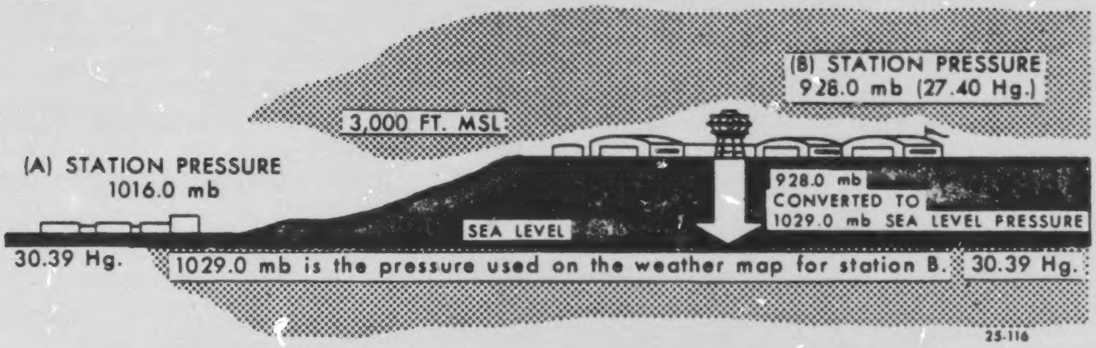


Figure 16. Conversion of station pressure to sea-level pressure.

5-8. *Station pressure.* Station pressure is the actual atmospheric pressure at your station in inches of mercury. This value, though not transmitted locally or longline, is the basis for determining other pressure values. Most weather stations locate their pressure measuring devices very close to the actual station elevation. For this reason, station pressure is usually the atmospheric pressure at the assigned station elevation.

5-9. When the aneroid barometer is considered accurate, you read station pressure to the nearest 0.005 inch of mercury directly from the aneroid barometer. In many cases, this reading requires no correction. If the aneroid and mercurial barometers show that there is a difference (taken comparison readings in accordance with FMH–1), enter a mean correction value on AWS Form 85, Barometer Comparisons, and apply it to the aneroid barometer reading. The chief observer usually posts this form on or near the aneroid barometer. Station policy determines who makes the comparison readings. Your responsibility is to apply the correction to the station pressure value before using it for other computations.

5-10. When the aneroid barometer is *relocated* or *replaced* by a new barometer, a new set of comparison readings is required as directed by FMH–1. After these comparison readings are made, the barometer can be used for pressure readings.

5-11. During a period when the aneroid barometer is being evaluated, or is considered inaccurate, the microbarograph is used to obtain station pressure. During this period, read the mercurial barometer every 6 hours, and if required, enter a correction on Form 10, line 65. This correction is applied to all subsequent microbarograph readings until another correction is obtained from the mercurial barometer. When this comparison reading difference exceeds 0.05, reset the microbarograph to the correct station pressure and consider the correction as zero for subsequent readings. When you have determined the station pressure by using one of these pressure measuring devices, you can compute the sea-level pressure.

5-12. *Sea-level pressure.* The sea-level pressure is the pressure at mean sea level (MSL) either directly measured if at sea level, or calculated if not at sea level. It is the reference level for all pressure values. Sea-level pressure is calculated from the station pressure, the 12-hour mean temperature, and the station elevation. Sea-level pressure is plotted on surface maps so that there is a standard pressure level. A standard pressure level is needed so that atmospheric pressures from several stations for one given time can be compared.

5-13. Referring to figure 16, you can see that Station A, located at sea level, reports sea-level pressure that is the same value as the station pressure, 1016 mb. Station B, located 3,000 feet above MSL, must compute an equivalent sea-level pressure (SLP), thus converting a station pressure of 928 mb to a SLP of 1029 mb.

5-14. Station pressure is reduced to sea-level pressure by either of two methods. The most common method is to use the pressure reduction computer (WBAN 54–7–8). The second method is to use prepared pressure reduction tables. Both of these methods are discussed in Volume 1, Chapter 2, Meteorology and Mathematics.

5-15. Regardless of the method you use to obtain sea-level pressure, the entry on Form 10 is reported using tens, units, and tenths digits. For example, a pressure of 1027.9 mb is entered as "279" in column 6. This entry, like most entries on Form 10, is prefixed with an "E" when it is estimated. Your computations will enable the forecaster to compare the pressure at your station with other stations. The pilot, on the other hand, requires a pressure value more suited to his needs—the altimeter setting.

5-16. *Altimeter setting.* The pilot usually obtains the altimeter settings from your observation. Consequently, each altimeter setting that you include with your observation should not only be accurate but must be representative of the existing pressure conditions. Criteria for *taking* and *disseminating* the altimeter setting are discussed later in Chapter 2; therefore, your primary concern at this time is why and how to record altimeter settings.

5-17. The altimeter setting is a calculated sea-level pressure in inches of mercury. The pilot uses it to adjust the altimeter of his aircraft. After he sets the current altimeter setting into the altimeter, the altimeter indicates field elevation when the aircraft is parked on the runway. Don't confuse altimeter setting with sea-level pressure, since the altimeter setting is determined by a correction based on the assumption that the hypothetical column of air between station elevation and sea level has the same temperature-pressure-height distribution as the U.S. Standard Atmosphere. Also each AWS station *adds .01 inch* to the computed altimeter setting to arrive at a value with reference to *field elevation.*

5-18. The altimeter in an aircraft is an aneroid barometer, calibrated to indicate altitude instead of pressure. For example, it indicates 10,000 feet when the ambient pressure is 20.58 inches, regardless of whether or not the altitude is actually 10,000 feet. When the altimeter is properly adjusted for the current altimeter setting, the indicated altitude corresponds to the equivalent pressure in the *standard atmosphere*.

5-19. By the same token, a pilot flying from a high-pressure (warm) area to a low-pressure (cold) area with a constant altimeter setting cranked into this altimeter finds that his true altitude varies both above and below the indicated altitude, as shown in figure 17. For this reason, a pilot changes the setting of his altimeter according to the altimeter setting changes that are supplied to him by controllers along his flight path. In this way he can use his altimeter to maintain a reasonably true altitude. This helps to eliminate the hazard of flying into other aircraft or mountains because of altimeter error.

5-20. The two ways to determine altimeter settings are covered in Volume 1, Chapter 2, Meteorology and Mathematics. You should already be familiar with the procedures, but here is a quick review of the two methods. Altimeter settings are determined by:

- Locally prepared conversion tables.
- Pressure reduction computer (WBAN 54-7-8).

A very important fact to remember is that regardless which method you use the altimeter setting should be based on *field elevation.*

5-21. Altimeter settings are recorded on AWS Form 10 in column 12, using units, tenths, and hundredths digits. For example, an altimeter setting of 29.98 inches is entered as "998." It is a rare situation when the altimeter setting drops below 29.00 inches; however, when it does, you need to prefix the value with the word "Low."

5-22. **Pressure Entries and Remarks.** Most pressure entries on AWS Form 10 are made quickly and easily. When the *aneroid barometer* is the primary pressure measuring device, only three columns (6, 11, and 17) on AWS form 10 are used for pressure in addition the Remarks column (column 13). When the *microbarograph* is the primary pressure measuring device, lines 59 through 65 of the AWS Form 10 are completed every 6 hours in addition to the regular entries.

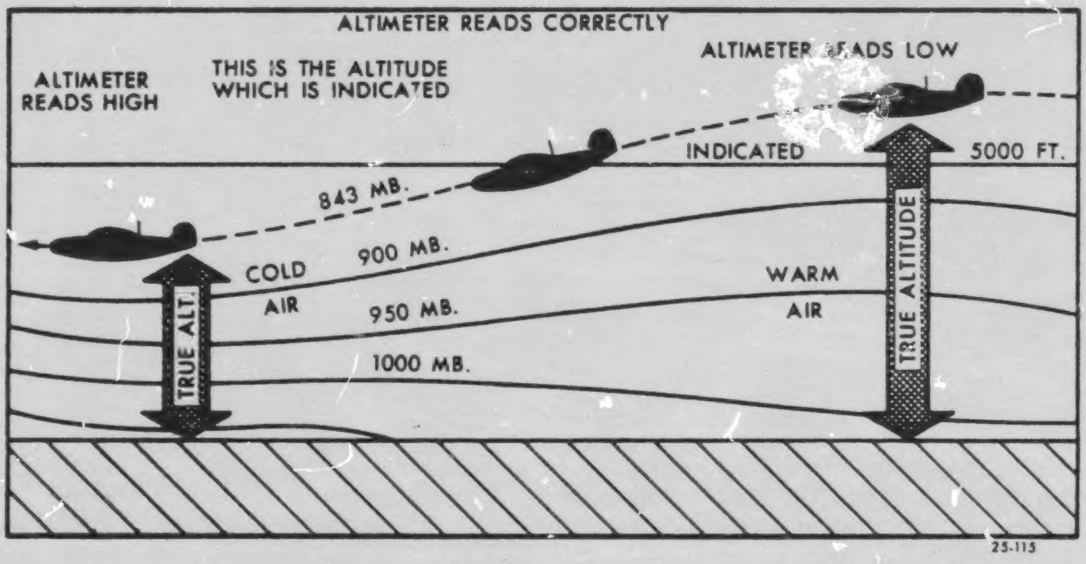


Figure 17. Flying from warm to cold air.

5-23. Pressure elements are normally determined as close to the hour as possible. You should plan to evaluate and record all other elements of your observation before you read the barometer. In this way, each weather station makes pressure readings at nearly the same time, thereby increasing the usefulness of the pressure values. Station pressure, though not transmitted, is recorded in column 17 of AWS Form 10 once every 3 hours to the nearest 0.005 inch of mercury.

5-24. *Station pressure computation (columns 17, and 59–65).* As indicated earlier, station pressure can be determined easily from the aneroid barometer. When you use the aneroid, you do *not* complete columns 59 through 65. However, when the microbarograph is used as the primary instrument, you *must complete* these columns.

5-25. To make the discussion easier to follow refer to foldout 4. The following entry rules apply to columns 59 through 65:

a. Column 59—the time the barometer is read.

b. Column 60—the temperature (nearest 0.5° F from the attached thermometer.

c. Column 61—the barometer reading to the nearest 0.001 inch.

d. Column 62—the total correction (correction card and temperature correction) to the nearest 0.001 inch.

e. Column 63—the algebraic sum of columns 61 and 62 (station pressure).

f. Column 64—the barograph reading to the nearest 0.005 inch.

g. Column 65—the difference between the barometer and barograph reading (rounded to the nearest 0.005 inch).

5-26. If the column 64 entry is greater than the column 63 entry, the correction entered in column 65 is prefixed by a minus sign; if less, a plus sign. This entry is to the nearest 0.005 inch and is the barograph correction for the next 6-hour period. If the barograph is reset, place an asterisk before the "zero" correction and make a note in column 90 (*barograph reset to zero correction at 1410 LST).

5-27. As you learned earlier, all transmitted pressure values that are entered on AWS Form 10 are based on a station pressure value that is rounded to the nearest 0.005 inch of mercury. At 3-hourly intervals you enter this pressure in column 17. Since so many other values are based on station pressure, make sure that you thoroughly check your station pressure readings. You can spot check previous observations to see that the station pressure from column 63 was rounded off properly. Other pressure entries on AWS Form 10 are significant pressure remarks recorded in column 13 to amplify this data.

5-28. *Significant remarks (column 13).* As for all elements of the observation, there are remarks concerning pressure that an observer should be prepared to report. Some of the more significant pressure remarks that you should report are as follows:

Pressure Occurrence	*Sample Remark*
Barogram "V" (must fall and rise at the rate of 0.06 inch per hour or more and both the rise and fall must equal 0.03 inch).	LOWEST PRES 832 2321 (lowest sea-level pressure and time of occurrence)
Rising or falling pressure (at the rate of 0.06 or more per hour).	PRESRR PRESFR
Unsteady pressure (sharp troughs or crests that depart from the mean trend average by at least 0.03 inch).	PRES UNSTDY
Pressure jump (reported only at stations using 12-hour microbarograph that experience a pressure rise at a rate exceeding 0.005 inch per minute).	PRJMP 8/1012/18 (jump of .08 inch that began at 1012 and ended at 1018)

5-29. AWS units do not normally have the equipment for reporting the pressure jump remark. However, to understand how this group is reported and coded by other weather agencies, consider the following facts. To enter a *pressure jump* remark the following criteria must be met:

a. Have a rise of at least 0.02 inch.

b. Have a rise that remains at least 0.02 inch higher than the original point of jump for 20 minutes or more.

c. Have a jump that is distinctly separated from the beginning of any *preceding jump* by at least 20 minutes, and a segment of the trace that is steady or falling, or has a rise less than 0.01 inch per 2 minutes.

5-30. Pressure remarks are not unlike other remarks. Certain remarks, such as PRESFR, are common, whereas remarks pertaining to lowest pressure are less frequent. Temperature and dewpoint entries, which are discussed in the following section, are similar to pressure entries in that they can be determined quickly under normal circumstances.

6. Temperature and Dewpoint

6-1. The Air Force uses two methods for obtaining temperature readings—by a psychrometer constructed of two standard thermometers and by an automatic sensing hygrothermometer. Both instruments are described in Volume 1. As a station standard, the hygrothermometer has first priority and the psychrometer second. From either of these, you obtain free air temperature directly. The hygrothermometer also gives the dewpoint temperature directly, but the psychrometer method involves additional work to obtain dewpoint.

6-2. **Free Air Temperature.** Temperature is one of the most common and easily understood measurements of weather. Besides its usefulness as a tool for analyzing frontal positions, temperature data is used by the pilot, along with pressure-altitude data, to compute the runway distance needed to reach takeoff speed. The temperature of the free air is sometimes called the *ambient temperature*. This means air freely moving about, unaffected by controlled heating or cooling sources.

6-3. The hygrothermometer sensor or psychrometer site is selected to best measure this free air temperature (a grass area is preferred). You read the hyrothermometer temperature scale directly, rounding off the nearest whole degree. For the psychrometer, read the dry bulb to the nearest 0.1 of a degree.

6-4. **Dewpoint.** The dewpoint *indicates the temperature to which air must be cooled, with constant water vapor content and pressure, to reach saturation capacity.* During humid weather, very little cooling is needed to reach the saturation temperature because the free air contains much moisture, and the saturation temperature is near the free air temperature. The dewpoint is important because it is the temperature beyond which further cooling produces visible condensation.

6-5. *Dewpoint observation.* The AN/TMQ-11 hygrothermometer now in use at most permanent observing stations, provides *direct reading* of both dewpoint and free air temperature on separate scales. Both scales are calibrated in 1° F increments. The psychrometer *does not* directly provide dewpoint; instead, it gives free air and wet-bulb temperatures from which the dewpoint is calculated. The wet-bulb temperature indicates the amount of cooling that results because of the evaporation of water from the wetted sack. The difference between the dry- and wet-bulb readings, called wet-bulb depression, completes the information needed to compute dewpoint from tables or a calculator. All values are recorded to the nearest 0.1°.

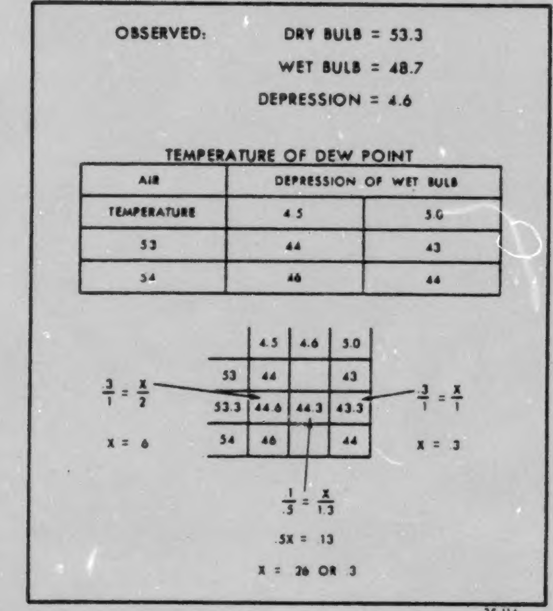


Figure 18. Sample interpolation.

TABLE 13

Station Elevation (feet)	*Computer Pressure Base (inches of mercury)*
−531 to +392	30"
+393 to +1341	29"
+1342 to 2316	28"
2317 to 3836	27"
3837 to 5976	25"
Above 5976	23"

6-6. *Dewpoint calculation.* Psychrometric tables offer one method of computing dewpoint. These tables list the dewpoints for a wide range of dry-bulb/wet-bulb depression relationships. Often your observed data falls between table values, and you must interpolate to obtain the correct dewpoint. Figure 18 illustrates a "double interpolation." You can see that interpolation is necessary between *air temperature* table values and *depression table* values, hence the term "double interpolation." A simple ratio and proportion solves the interpolation. For example, the observed dry-bulb temperature, 53.3, falls 0.3 of the 1° difference between 53 and 54, and the corresponding dewpoint also falls 0.3 of the distance between 44 and 46. Since 0.3 of 2 (the difference between 44 and 46) is 0.6, the answer is 44.6. As you solve each interpolation (indicated by arrows), you obtain the dewpoint (middle arrow). The dewpoint may equal the dry- or wet-bulb temperature, but it should never be higher than either. A second and the recommended method for calculating dewpoint involves the use of the psychrometric calculator ML-249/UM.

6-7. The calculator computes dewpoint by comparing the wet-bulb temperature with the wet-bulb depression at the average station pressure. Table 13 lists average station pressures for several ranges of station elevation. Select the pressure to determine which D scale (colored rings) to use on the computer. Next, select the *high range side* of the computer if the *wet-bulb* temperature is above 32° F or the *low range side* if it is below 32° F. Then follow the listed steps.

a. Set the 0° index of the D scale opposite the wet-bulb value on the "Ti" scale if the wet-bulb wick is ice covered, or opposite the DP scale if the wick is unfrozen.

b. Move the cursor to the wet-bulb depression along the colored D scale.

c. Read the dewpoint on the DP scale under the cursor hairline. Before you make the AWS Form 10 entry, insure that the scale you use does not result in a dew-point that is higher than the free air temperature.

6-8. **AWS Form 10 Entries.** Enter the temperature reading in column 7 and the dewpoint reading in column 8. Round off both entries to the nearest whole degree, and when an entry is below 0°F, prefix a minus sign. One-digit values do not need a zero prefix, such as 04 for 4. Some typical entries are shown as follows:

Column 7	*Column 8*
6	−15
43	38
101	62

The next AWS Form 10 entries that you must make are wind direction and speed.

7. Wind

7-1. Air has characteristics, such as temperature, moisture, and movement. Air movement sometimes produces unusual conditions in certain areas. These conditions have been given names such as "Chinook" on the leeward side of the Rockies, "nor'easter" in New England, "blizzard" in the Midwest, and "Santa Ana" in California. Some winds affect large areas while others occur on a local scale. Whatever their extent, wind observation includes direction, speed, and character.

7-2. **Direction and Speed.** The direction from which the wind blows gives its name to the wind. A west wind is one coming from the west. Two geographic points—the true north pole and the magnetic north pole—are the reference for any direction. The observing equipment is oriented to magnetic north. AWS Form 10 entries require a true north orientation. Therefore, between observation and entry, you must convert from one reference point to the other.

7-3. Direct-reading recorders, such as the RO–2, have priority as a standard over other wind measuring devices. Where the recorder is unavailable, the direct-reading dial of the AN/GMQ–11 wind measuring set is the station standard. The RO–2 recorder scale above the recording pen is usually adjusted to indicate wind direction with respect to *true* north, while the chart is set to *magnetic* north. You read the wind direction to the nearest 10° for a 1-minute average at the time of observation. Rarely does the recorder pen scribe a straight line; it usually swings across a wide range of directions. You choose the direction that occurs most frequently during the 1-minute period. The direct-reading dial of the wind set indicator offers

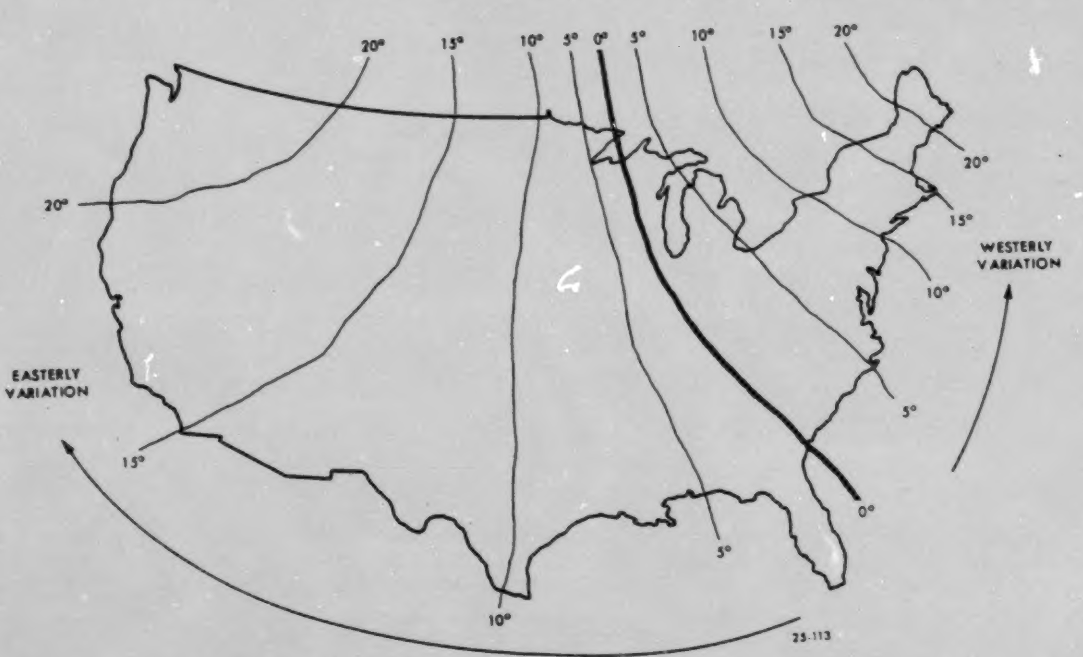


Figure 19. Magnetic variation.

only magnetic direction; therefore, you must convert the indication to a true direction.

7-4. *True and magnetic direction conversion.* The line along which the true and magnetic directions are the same is called the *agonic line* or 0° magnetic variation. As shown in figure 19, variations on one side of the line are termed easterly variations and variations on the other side are westerly variations. Obtain your local magnetic variations from a current sectional aeronautical chart. Then, to convert magnetic direction to true direction:

- ADD EASTERLY variation to magnetic direction.
- SUBTRACT WESTERLY variations from magnetic direction.

If you find it necessary to convert from *true* direction to *magnetic* direction:

- ADD WESTERLY variation to true direction.
- SUBTRACT EASTERLY variation from true direction.

7-5. *Estimating wind direction and speed.* On occasion, it may be necessary to estimate the wind direction. When this situation arises you can use the movement of leaves, smoke, or similar free moving objects to determine wind direction. If a wind cone or tee is available, you should have little trouble estimating the direction. Estimating wind speed can pose a little more of a problem.

7-6. When instruments are not available, estimate the speed (including character, discussed later in this section) from the Beaufort wind scale, as shown in table 14. The speed indicators also swing across a wide range of values which makes it difficult to determine the observed speed. This is

TABLE 14

ESTIMATION OF WINDSPEED

Beaufort Number	MPH	Knots	International Description	Specifications
0	Less than 1	Less than 1	Calm	Calm; smoke rises vertically
1	1-3	1-3	Light air	Direction of wind shown by smoke drift but not by wind vanes
2	4-7	4-6	Light Breeze	Wind felt on face; leaves rustle; vanes moved by wind
3	8-12	7-10	Gentle Breeze	Leaves and small twigs in constant motion; wind extends light flag
4	13-18	11-16	Moderate	Raises dust, loose paper; small branches moved
5	19-24	17-21	Fresh	Small trees in leaf begin to sway; crested wavelets form on inland waters
6	25-31	22-27	Strong	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty
7	32-38	28-33	Near gale	Whole trees in motion; inconvenience felt walking against wind
8	39-46	34-40	Gale	Breaks twigs off trees; impedes progress
9	47-54	41-47	Strong gale	Slight structural damage occurs
10	55-63	48-55	Storm	Trees uprooted; considerable damage occurs
11	64-72	56-63	Violent storm	Widespread damage
12	73-82	64-71	Hurricane	

especially true at speeds over 10 knots. Your judgment plays an important part in this case, since the rule specifies a 1-minute average wind speed. However, as in the case of wind direction, choose the speed observed most frequently. Other reporting methods cover the wide range of speed values under the terms "gust" and "squall."

7-7. **Wind Character.** A simple report of speed and direction does not always completely represent the observed wind. The terms "gust," "squall," and "wind shift" help describe characteristics of the wind not revealed by speed and direction.

7-8. Gustiness complicates aircraft touchdown and takeoff maneuvers in a manner that is similar to, but much more serious than, the handling effects you feel while driving a car during gustiness. Further importance is added to gusts by their association with frontal passage and thunderstorms. Wind seldom maintains a totally steady speed; a wind that is not gusty often shows a variation between peaks and lulls of about 6 knots. This is recognized on the wind recorder as a narrow ink trace whose edges show minor wiggles or ripples. A gust is characterized by rapid fluctuations in speed. The recorder ink trace widens and the edges are jagged, having pronounced projecting points and notches. A gust is further defined in FMH–1 by a specific speed criterion between peaks and lulls. This criterion serves to standardize gust reporting among all observing units. Gusts are identified by the symbol "G," followed with the peak speed observed during the 10 minutes prior to the ascribed observation time.

7-9. A squall is characterized by a sudden increase in windspeed which is sustained long enough to show a marked change in the average speed. Part of the success in observing wind rests upon distinguishing a squall from a gust. A squall is not simply an increase in the peak gust speed. The average wind speed must show a sudden, significant increase. Also, the speed must attain a certain level and remain above that level for a specified period of time. FMH–1 details the criteria for reporting a squall. It is common to have gusty winds during a squall, especially if the squall lasts for several minutes. A squall is identified by the symbol "Q," followed with peak speed observed during the same 10 minutes.

7-10. Wind shifts (change in direction of 45° or more within 15 minutes) are normally associated with some or all of the following phenomena, typical of a cold frontal passage:

- Gusty winds.
- Clockwise shift (Northern Hemisphere).
- Rapid drop in dewpoint.
- Rapid drop in temperature.
- Lightning, thunder, heavy rain, and hail in the summer.
- Rain or snow showers.

Wind shift entries, with or without frontal passage, are entered in column 13 of AWS Form 10. The standard contraction for wind shift is "WSHFT" and for frontal passage, "FROPA." Follow each wind shift remark with the time (GMT) of shift, such as WSHFT 1508 FROPA. Other remarks concerning variability of speed or direction may also be entered. In each case, use contractions.

7-11. **Wind Entries and Remarks.** Enter the wind direction in column 9 and wind speed in column 10 of AWS Form 10. Use two digits for each entry. Enter the direction in tens of degrees to the nearest ten degrees, and the speed to the nearest whole knot. A wind from 275° at 8 knots is written as "28" in column 9 and "08" in column 10, but is usually encoded "2808" for local dissemination. Even calms and speeds in excess of 100 knots require only four digits; for example, a calm is entered as "0000," and a 105-knot wind from 160° (16 + 50 = 66) is entered as "6605." Note the 50 added to *direction* when speed exceeds 100 knots. Be sure to enter a north wind as "36" rather than "00," and if you estimate the wind from the Beaufort scale, attach an "E" following the four digits.

7-12. When any of the phenomena listed below occur, you should add wind remarks to your observation:

- Hail
- Thunderstorms
- Tornadic activity

For example, when these severe weather phenomena occur, you should add a standard remark of "PK WND" to your observation, followed by the direction and speed, separated by a slant, and the time of occurrence in minutes past the hour. If a thunderstorm begins and the speed reaches 37 knots from 270° at 1146 GMT, you would record the following remark in column 13 on 9WS Form 10 and transmit:

PK WND 27/37 46

You would repeat this remark on the next record observation following the ending or disappearance of the phenomenon.

7-13. If the wind speed attains 35 knots or more and no severe weather is present, you should record a "PK WND" remark for the first occurrence using the preceding rules. Other common wind remarks are:

Type	*Sample Remark*
Variable wind direction	WND 270V320
Magnetic wind direction (only reported by stations transmitting winds locally by teletype)	MAG16

7-14. Columns 71, 72, and 73 are used to enter information about the peak wind for the day (refer to foldout 4). Column 71 is used to record the highest instantaneous speed recorded during the 24 hours ending at midnight. It is entered in tens of degrees. If the direction portion of the recorder is inoperative, the direction must be estimated from column 9 data and entered in column 72 to the eight points of the compass (i.e., E, SE, S. etc.). Column 72 is used to report the true direction and column 73 the time of occurrence. If the same speed occurs more than once, enter the time of the last occurrence with a footnote reference. and in block 90, enter the additional times.

7-15. Most experienced observers record their AWS Form 10 entries in the same order they are listed; that is, sky condition first, visibility next, and so forth. This method of completing your observation usually presents no major problem. Not only must you assemble in column 13 the entries we have already discussed, but you also need to enter supplementary data (coded groups and additional data) in this column. Supplementary data is discussed in the next section of this CDC.

7-16. Before proceeding to Section 8 refer to the chapter review exercises in your workbook and answer the items for Sections 5, 6, and 7.

8. Supplementary Data

8-1. Supplementary data is encoded and entered in column 13 of AWS Form 10. The intent of these entries is to record operationally significant information not reported elsewhere; to elaborate on preceding coded data; or to record for dissemination supplementary 3- and 6-hourly synoptic data.

8-2. To make it easy to locate information in a weather message, an order of entry has been established. You should already be familiar with the order of entry for operationally significant remarks from the previous sections, but here is a quick review, plus the order of entry for additional remarks covered in this section.

a. Operationally significant remarks.
- Runway visual range or runway visibility.
- Surface-based obscuring phenomena.
- Wind shifts.
- Pilot and radar reports of bases and tops.
- Remarks elaborating on the observation.

b. Coded groups (3- and 6-hourly additive data).
- Barometric and precipitation data.
- Cloud code group.
- Snow depth.
- 24-hour precipitation.

c. Additional entries.
- Radiosonde data (RADAT).
- Runway conditions.
- Weather modification.
- Radiological data (RIII group).

8-3. Some of the preceding requires the use of codes. Where plain language is called for, use authorized contractions and weather symbols to conserve communication time and space. However, never omit an essential remark, of which you are aware, for the lack of readily available contractions or symbols. In such cases the only requirement is that the remark be clear. Make all time entries in GMT with the time zone indicator omitted. Report the direction in which clouds or other phenomena are moving. When using points of the compass to describe quadrants or sectors, enter them in a clockwise order, e.g. "N–E." The next category, coded groups, is discussed in the sequence in which the groups are entered on AWS Form 10.

8-4. **Coded Groups.** Coded groups are included only with the 3- and 6-hourly observations. They contain barometric data, precipitation amounts and depths, international cloud types, and precipitation data. The first coded group contains barometric data.

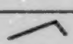
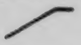
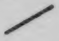
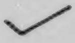
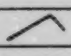
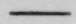
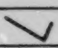
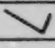
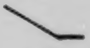
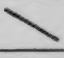
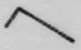
8-5. *Barometric data (app 99ppp).* Barometric data includes both the barometric *characteristics* (trace) and *tendency* (amount). The first element, "a," is the characteristic of the barograph trace. The coded value for this element is determined every 3 hours by observing the trace on the microbarograph and then selecting the coded value, as shown in table 15, that best represents the past 3-hour period.

8-6. Whenever the barogram trace is incompatible with the previous pressure readings (3 hours ago), you should check the column 12 and 17 entries on AWS Form 10. For example, you cannot encode a barometric characteristic (trace) of "3" when the pressure is lower than it was 3 hours ago. Even though the barogram reveals a pressure trace that resembles the code value "3," the correct code value is "5," which signifies a similar condition. The main difference is that the pressure is lower than it was 3 hours ago.

8-7. Column 1 of table 15 shows the criteria for determining the coded value for "a." Column 2 shows the general characteristic the barogram trace must assume. The code values "2" and "7" are used for pressure situations which preclude the coding of other code values. Notice that only three code values (0, 4, and 5) can be coded when the 3-hour change is ±.000.

8-8. The element "pp" is the amount of barometric tendency (change) for the past 3 hours. This change is the difference, to the nearest 0.005 inch, between the column 17 entry at observation time and the previous column 17 entry. This difference is then converted to a coded value, as shown in table 16, which together with the barometric characteristics form the "app" group. For example, a pressure trace for the past 3 hours indicates a falling and then steady trace. The total

TABLE 15
DETERMINATION OF CHARACTERISTIC OF BAROMETER TENDENCY

Description of Characteristic		*Graphic Representation*	*Code Figure*
Primary Unqualified Requirement	Additional Requirements.		
HIGHER Atmospheric pressure now higher than 3 hours ago	Increasing, then decreasing.		0
	Increasing, then steady; or increasing more slowly.		1
	Increasing steadily; or increasing unsteadily.		2
	Decreasing or steady, then increasing; or increasing, then increasing more rapidly.		3
THE SAME Atmospheric pressure now same as 3 hours ago	Increasing, then decreasing.		0
	Steady or unsteady.		4
	Decreasing, then increasing.		5
LOWER Atmospheric pressure now lower than 3 hours ago	Decreasing, then increasing.		5
	Decreasing, then steady; or decreasing, then decreasing more slowly.		6
	Decreasing steadily or decreasing unsteadily.		7
	Steady or increasing, then decreasing, or decreasing, then decreasing more rapidly.		8
Column 1	Column 2	Column 3	Column 4

pressure change from the three hours is .035 inch. Therefore, the "app" group should be coded "612."

8-9. When the pressure characteristic ("a") or pressure tendency ("pp") are not obtainable, replace them with the appropriate number of slant lines. For example, an "app" group with a characteristic of "3" and no tendency data is encoded "3//." If no column 17 reading is available for the last 3-hour period, you can use the station pressure from the microbaragraph reading of 3 hours ago if the equipment is reliable; otherwise, report the data missing.

8-10. If the barometric tendency, "pp," equals or exceeds code value "99," use the code "99" for the barometric tendency and report an additional group. The group 99ppp follows the basic "app" group when the code values are "99" or higher. For example, a 3-hourly pressure characteristic of "2" and a barometric tendency of .340 inch is coded "299 9915."

8-11. *Precipitation amount (RR).* At 6-hourly report intervals, the precipitation amount (RR) is combined with the "app" group. This attached "RR" element represents the total precipitation (water equivalent) for the past 6-hour period and is coded in tenths and hundredths. For example, an "app" group of 803 and a precipitation amount of 0.28 inch for the past 6 hours is encoded "80328" on AWS Form 10. When there has been precipitation, but the measurement is less than 0.01 inch, the "RR" is coded as "00" (trace).

8-12. When the precipitation amount in the last 6 hours is 1 inch or more, you add a plain language remark after the basic group to indicate the whole inches measured. For example, a complete appRR (99ppp) grouping of data that includes 2.36 inches of precipitation is coded "89936 99117 TWO." In addition to the "RR" data, this example illustrates the way that the barometric data is combined and arranged for entry on AWS Form 10. The next coded group, cloud code group, was discussed in detail in Section 1 of this chapter. Therefore, the following discussion of this group is very brief.

8-13. *Cloud code group ($1C_LC_MC_H$).* When clouds are observed, the cloud code group is coded as shown in Section 1 of this chapter. This code group always follows the "app" on a 3-hourly and the "appRR" coded date on a 6-hourly report. When clouds are not present or you cannot see them because of complete obscuration, omit the cloud code group. The cloud code group is followed by the snow depth group when certain conditions exist.

8-14. *Snow depth ($904S_pS_p$).* The snow depth group is reported on 6-hourly observations when there is more than a trace of snow on the ground and more than a trace (water equivalent) of any form of precipitation occurs during the past 6 hours. The snow depth group is always reported at 1200 GMT when there is more than a trace of snow on the ground. The "904" is an international indicator for "snow depth," and the "S_pS_p" represents the inches of snow on the ground. For example, 15 inches of snow at 1200 GMT is coded "90415." When more than 99 inches of snow is present, the basic group is repeated. For example, 213 inches of snow depth is coded "90499 90499 90413." Many AWS stations never have occasion to report snow. There are, however, many stations in a temperature zone that report snow a few times throughout the year. If you are at these stations, avoid procedural difficulty in reporting snow depth by studying the rules for observing, evaluating, recording, and disseminating this information when the need arises.

8-15. The measuring stick used with the rain gage is also used to measure total snow depth. Determine the depth to the nearest 0.1 inch as far as practicable. For measuring the depth of undrifted snow, sink the measuring stick vertically into the snow so that the end rests on the ground surface

TABLE 16

SYMBOLS "PP" AND "PPP" - AMOUNT OF BAROMETRIC CHANGE IN THE LAST 3 HOURS

Amount of rise or fall											
pp						ppp					
Code figure	Inches of mercury	Millibars	Code figure	Inches of mercury	Millibars	Code figure	Inches of mercury	Millibars	Code figure	Inches of mercury	Millibars
00	0.000	0.0				100	0.295	10.0			
02	.005	.2	52	0.155	5.2	102	.300	10.2			
03	.010	.3	54	.160	5.4						
05	.015	.5	56	.165	5.6	103	.305	10.3	154	0.455	15.4
07	.020	.7	58	.170	5.8	105	.310	10.5	156	.460	15.6
08	.025	.8	59	.175	5.9	107	.315	10.7	157	.465	15.7
						108	.320	10.8	159	.470	15.9
10	.030	1.0	61	.180	6.1	110	.325	11.0	161	.475	16.1
12	.035	1.2	63	.185	6.3						
14	.040	1.4	64	.190	6.4	112	.330	11.2	163	.480	16.3
15	.045	1.5	66	.195	6.6	113	.335	11.3	164	.485	16.4
17	.050	1.7	68	.200	6.8	115	.340	11.5	166	.490	16.6
						117	.345	11.7	168	.495	16.8
19	.055	1.9	69	.205	6.9	119	.350	11.9	169	.500	16.9
20	.060	2.0	71	.210	7.1						
22	.065	2.2	73	.215	7.3	120	.355	12.0	171	.505	17.1
24	.070	2.4	75	.220	7.5	122	.360	12.2	173	.510	17.3
25	.075	2.5	76	.225	7.6	124	.365	12.4	174	.515	17.4
						125	.370	12.5	176	.520	17.6
27	.080	2.7	78	.230	7.8	127	.375	12.7	178	.525	17.8
29	.085	2.9	80	.235	8.0						
30	.090	3.0	81	.240	8.1	129	.380	12.9	179	.530	17.9
32	.095	3.2	83	.245	8.3	130	.385	13.0	181	.535	18.1
34	.100	3.4	85	.250	8.5	132	.390	13.2	183	.540	18.3
						134	.395	13.4	185	.545	18.5
36	.105	3.6	86	.255	8.6	135	.400	13.5	186	.550	18.6
37	.110	3.7	88	.260	8.8						
39	.115	3.9	90	.265	9.0	137	.405	13.7	188	.555	18.8
41	.120	4.1	91	.270	9.1	139	.410	13.9	190	.560	19.0
42	.125	4.2	93	.275	9.3	141	.415	14.1	191	.565	19.1
						142	.420	14.2	193	.570	19.3
44	.130	4.4	95	.280	9.5	144	.425	14.4	195	.575	19.5
46	.135	4.6	97	.285	9.7						
47	.140	4.7	98	.290	9.8	146	.430	14.6	196	.580	19.6
49	.145	4.9	99	.295	10.0	147	.435	14.7	198	.585	19.8
51	.150	5.1		.300	10.2	149	.440	14.9	200	.590	20.0
				etc.	etc.	151	.445	15.1	201	.595	20.1
						152	.450	15.2	203	.600	20.3

and read the measurement. Repeat this procedure at several spots and average the readings for the total snow depth.

8-16. When the snow has drifted, a reasonably accurate total depth measurement can be made by taking the average of several measurements over representative areas. Be sure to include the greatest and least depths. For example, if spots with no snow are visible, at least one of the values used in the computation should be zero.

8-17. *24-hour precipitation* $(2R_{24}R_{24}R_{24}R_{24})$. As the symbolic code form implies, this precipitation group is coded only once every 24 hours at 1200 GMT. This group is also coded in the international weather code (synoptic code); therefore, at some locations in the world, coding instructions may vary.

8-18. Generally, the 24-hour amount of precipitation is determined from a sum of the 6-hourly measurements that are required for AWS Form 10 entries. Since you are not required to keep a record other than the coded 6-hourly data, it is to your advantage to extract the 24-hour precipitation information before the 1200 GMT observation. We have already discussed the ways of determining water equivalents.

8-19. The 24-hour precipitation amount is entered in column 13 in the coded format "$2R_{24}R_{24}R_{24}R_{24}$." The "2" is the code group indicator and the "$R_{24}R_{24}R_{24}R_{24}$" portion of the group indicates tens, units, tenths, and hundredths of an inch of precipitation. The decimal point is omitted in the entry. For example, 1.38 inches of precipitation is coded "20138." When 0.01 inch or more precipitation occurs during the preceding 24 hours and you cannot determine the amount, enter "2////" in column 13. When no precipitation occurs during the 24 hours, omit the coded entry.

8-20. **Additional Entries.** Most stations append additional groups to their observations. Additional entries can be distinguished from coded groups because most additional entries are in the form of plain language and contractions rather than coded groups. The additional entries increase the usefulness of the observation for local operations, such as flying. The first additional entry, freezing level data, is useful in studying the dynamics of the atmosphere and for briefing purposes.

8-21. *Freezing level data (RADAT).* Freezing level data is transmitted from stations that have a rawinsonde section. This data is determined from the raob balloon sounding when it passes through the freezing level stratum (0° C). This information, when available, is added to the first hourly observation following the receipt of the data.

8-22. The contraction "RADAT" signifies that freezing level data follows. The contraction RADAT is followed by one of three entries as follows:

a. A five- to fourteen-digit group UU(D) $(h_ph_ph_p)(h_ph_ph_p)$(/n).
b. MISG.
c. ZERO.

8-23. The contraction "MISG" indicates that the surface temperature is warmer than 0° centigrade and the sounding is terminated before the 0° centigrade isotherm is reached. The entry "ZERO" indicates that the entire sounding was below freezing. When neither of these conditions exists, the contraction "RADAT" is followed by a five- to fourteen-digit group.

8-24. The first two digits (UU) are relative humidity at the first crossing of the 0° C isotherm. When it is 100 percent, "00" is entered; 20 percent is entered as "20"; and when it is 10 percent or less, "10" is entered. When the relative humidity is missing, "//" is entered.

8-25. The third digit (D) is a letter designator identifying the 0° C isotherm crossing to which the coded value of UU corresponds;

- L—for lowest.
- M—for middle.
- H—for highest.

When only one height value is coded, this figure is omitted.

8-26. The symbolic letters "$h_ph_ph_p$" represent the height of the first freezing level in hundreds of feet MSL. For example, RADAT 37015 shows a relative humidity of 37 percent at a freezing level of 1,500 feet MSL.

8-27. When the raob sounding crosses more than one freezing level, additional $h_ph_ph_p$ groups are added to the report. For example, RADAT 84M019045051/1 indicates the following:

- 84M—Relative humidity at the middle coded height (045) of the 0° C isotherm crossing is 84 percent.
- 019—Height at which sounding first crosses 0° C isotherm is 1,900 feet MSL.
- 045—Height of next to uppermost level at which sounding crosses 0° C isotherm is 4,500 feet MSL.
- 051—Height of uppermost level at which sounding crosses 0° C isotherm is 5,100 feet MSL.
- /1—Indicator to show that one additional crossing of the 0°C isotherm occurred.

8-28. The last group (/n) is an indicator group used to show the number of crossings of the 0° C isotherm other than those whose heights are coded. If all the crossings are coded in the report, then the (/n) group is omitted.

8-29. *Icing data (RAICG).* When icing level data is determined from a Raob sounding, append this information to the observation. Icing data is of primary concern to forecasters when they are briefing pilots. This group, RAICG, reveals potential aircraft icing conditions. The coding instructions are similar to those for "RADAT" data. An icing level at 14,000 feet MSL is coded "RAICG 14MSL."

8-30. If the sounding's ascension rate is apparently slowed by snow, the contraction "SNW" is entered following the height data, as shown in the code group "RAICG 13MSL SNW."

8-31. Both RADAT and RAICG, of course, are appended to the observation *only* when you have a rawinsonde section at your station, and then only if they meet the criteria mentioned in the preceding discussion.

8-32. *Runway condition.* Runway condition data is provided by the base operations officer when he thinks the condition of the runway is such that aircraft operations could be affected. When received from the base operations officer, this data is appended to the observation and is disseminated over longline weather communication circuits only. After initial longline dissemination, it is appended to all subsequent hourly observations until amended or canceled by the base operations officer.

8-33. The following contractions are used to report the runway surface condition:

WET RWY—Wet runway.
SLR—Slush on runway.
LSR—Loose snow on runway.
PSR—Packed snow on runway.
IR—Ice on runway.
P—Patchy conditions (attached to runway condition reading).

8-34. Except for "WET RWY" these runway surface conditions contractions are followed by a two-digit decelerometer reading. The decelerometer reading value varies between 02 and 26. Two typical examples are:

(1) PSR15 (packed snow on runway; decelerometer reading, 15.)
(2) IR05P SANDED (ice on runway; decelerometer reading 05; conditions patchy, runway sanded.)

8-35. *Weather modification.* Weather modification activities involving fog and stratus dispersal are sometimes conducted. If this occurs at your station, you must be aware of how and when to enter this data in column 13 of AWS Form 10. There are four cases when weather modification remarks are included with the official observation:

- When they are about to take place.
- When they are taking place.
- When they have ended.
- When dispersal efforts may cease to affect the terminal weather.

8-36. Dispersal activities are reported in the first "S" or "R" observation transmitted longline. If notice is received that dispersal will take place several hours in advance of the actual weather modification period, you should be briefed at that time to report this data no sooner than 2 hours preceding the time that the dispersal activities begin. When dispersal activities end or are scheduled to end, a remark is appended to either the next record observation or to the preceding record if notification is given before the dispersal activities are completed. Below is a list of typical weather modification remarks:

a. F DSPRL B0910 (time began or scheduled to begin).

b. ST DSPRL BUNKN (activity began but actual time unknown).

c. F DSPRL CONTG (activity continuing; reported in each record until ended).

d. F DSPRL E1620 (time activity ended).

e. F DSPRL SKEDD E1417 (activity scheduled to end).

f. ST DSPRL EFF SKEDD E 1702 (dispersal agent effective only to estimated time).

8-37. *Radiation intensity (RIII).* If you are assigned to a weather unit within the CONUS or Alaska, you are only responsible for transmitting radiation intensity (K data) (RIII) under specified conditions—usually during the period in which DEFCON (defense condition) 3 or higher is declared. At overseas locations, the theater commander determines the reporting criteria. Because of varying criteria, we have purposely omitted this from the text. The examples listed below are typical radiation group data:

a. RZERO (no radiation).

b. R012 (12 r/hr).

c. R127 Plus 1000 (for values that exceed 999 r/hr, subtract the thousand value and encode the remainder as b, above. Add the thousands value in plain language).

d. R/// (data unavailable).

9. Miscellaneous AWS Form 10 Instructions

9-1. Up to this point, our discussion of AWS Form 10 entries has dealt primarily with columns 3 through 13. You form these entries into a surface airways report and transmit or disseminate the report to support aircraft and forecasting operations. The remaining Form 10 columns are space for statistical data, important enough for entry but not necessarily desired for transmission. This section discusses those columns as well as general rules governing Form 10 entries and corrections.

9-2. **Statistical Columns.** Several of the statistical columns are discussed in Section 5, Pressure, where the entries closely support one another. These entries are column 17, Station Pressure, and Columns 59 through 65, Station Pressure Computation. This section does not duplicate that discussion. Broadly speaking, the remaining statistical columns fall into four classes:

a. Total sky cover, column 21.

b. Synoptic data, columns 42, 44, 45, 46.

c. Summary of the day, columns 68, 69, 70, 71, 72 and 73.

d. Remarks, notes and miscellaneous phenomena, column 90.

9-3. To make the discussion easier to follow, open foldout 4 and refer to it while reading this section. The following rules apply to Total Sky Cover, column 21. This column summarizes total sky cover for each record observation. The tenths value that is entered represents the last sky cover symbol in column 3 whether thin or opaque; for clear sky enter "0." Column 21 is the only hourly summary column. The next columns are synoptic data columns.

9-4. *Synoptic data.* Foldout 4 illustrates entries in these columns for a 24-hour observing day. Column 42 entries divide the observing day into periods of time between 6-hourly observations from midnight to midnight. The entries are for local standard times at which 6-hourlies are taken. The "Mid to 0543" covers the period from 0000 LST to 0543 LST. The period from the *last 6-hourly of the previous day* to the 6-hourly at 0543 is summarized on the next line.

9-5. In column 44, enter the amount of total precipitation (liquid and water equivalent of solid precipitation) that falls during each period specified in column 42. Enter amounts in inches and hundredths or "T" for trace and "0" for no precipitation.

9-6. Column 45 is used to enter the amount of solid precipitation that occurred in the 6-hours preceding the observation. Column 46 is used to record the accumulated solid precipitation depth at the time of the 6-hourly precipitation.

9-7. The important thing to remember is that these columns (45 and 46) actually apply to all solid forms of precipitation, and since hail and ice pellets are uncommon occurrences, you should check to see whether the proper entries have been used as directed by FMH–1. Particularly when hail or melting occurs, operationally significant remarks are required in column 90.

9-8. *Summary of the day (columns 68–73).* Record the total 24-hour precipitation that occurs from "mid to mid" in column 68. From foldout 4 this represents the sum of the amounts in column 44. Record the 24-hour, mid to mid snowfall in column 69. Again this is the sum of amounts in column 45. The total snowfall with the "0" indicates no actual depth accumulated. Column 70 represents the depth of solid precipitation on the ground at 1200 GMT as measured to the nearest inch.

9-9. There are summary columns for peak wind speed and direction during the 24 hours ending at midnight. Enter this data only when the station has a continuous wind recorder, such as the RO–2 or GMO–20. Column 71 provides for entry of the peak speed entry to the nearest knot. Column 72 provides for entry of direction in tens of degrees and is recorded as two digits, and column 73, the local standard time of peak wind speed occurrence. If the same speed occurs more than once, enter the time of the last occurrence with a footnote reference, and in column 90 enter the additional times.

9-10. *Column 90.* Column 90's title, Remarks, Notes, and Miscellaneous Phenomena, explains its purpose adequately. This column is space for all the explanations to clarify entries in other columns or to describe conditions affecting recorded observations. A few brief examples are listed.

- Miscellaneous hydrometeors, such as glaze, rime, frost.
- Luminous meteors, such as aurora, halo, corona.
- Storm damage from hail, wind, or flood.
- Tornado, funnel cloud, or waterspout.

Data regarding tornadoes that is not entered in the column 13 remark, such as path width, cloud appearance, rate of movement, type of path (straight or swerving), is entered in column 90.

9-11. There are numerous remarks about the precipitation summary columns listed in FMH–1, which should be recorded in column 90. For example, note in foldout 4 that when hail falls and the amount in column 45 has an asterisk (*) attached, the remark "*Hail" is entered in column 90. Keep in mind that column 90 remarks clarify entries in other columns. This can be important after an aircraft mishap when the investigating board is seeking causes for the mishap.

9-12. Active runway and equipment change remarks are entered in column 90. Enter the time (LST) and active runway when weather sensor equipment is changed as a result of a change in the active runway. An entry is not required on a new page for the same day of the form unless a change actually occurs. On the first page for each new day, enter the active runway number currently in use.

9-13. **General Rules.** Any organized recording form, such as AWS Form 10, needs rules to regulate its use. Rules covering legibility, data separation, missing entries, statistical data, observation identifiers, and contractions fall under general rules. Occasionally, a mistake is made; therefore, provisions are needed to correct the mistakes.

9-14. *Recording rules.* When you make an entry, make it legible. Avoid fancy penmanship. Use bold, capital letters (small letters have too many individual styles) that fill about three-fourths of the vertical space between lines. *Legibility* is the key point.

9-15. Any data entered in column 13 that is *not intended for longline transmission* is set off in parentheses ( ). The 1-minute runway visibility entry illustrates this. When you find it necessary to separate data to avoid confusion between coded groups, use a slant line (/). One particular use of the slant occurs between remarks and the 3- or 6-hourly coded data. Slant lines also indicate missing data or undeterminable data when you use it in 3- or 6-hourly coded groups. When specific data is missing in individual columns, the proper entry there is "M."

9-16. Each observation you make is identified. This identification includes observation type, observation time, and observer. Observation type, R, RS, S, or L, is entered for record, record special, special, or local in column 1, whereas column 2 provides for the observation time entry. The time refers to the time that you actually *observed* the last element. The "filing time" is when you deliver your report to communications or transmit it. Column 2 times are in local standard time, and column 13 times are in Greenwich mean time. Each 15° of longitude equals 1 hour's difference from Greenwich time. West longitude is earlier than Greenwich, and east longitude, later. You, as the observer, make the last identification for the observation by entering your initials in column 15.

9-17. *Corrections.* Two rules apply to corrections. One is for errors discovered before dissemination, the other for errors discovered after dissemination. In the first case, simply erase or draw a line through the error and make the correct entry. For errors that you discover after dissemination, draw a red line through the incorrect entry and make the correct entry in red above the error. If the correction is transmitted, enter "COR" in red in column 13 and follow it by the "filing time" or "actual transmission" time if you make the transmission. Remember, discovering a mistake and *doing nothing about it* is a greater error than just making a mistake.

9-18. Refer to the chapter review exercise items in your workbook and answer the items for these last two sections of Chapter 1.

CHAPTER 2

Encoding and Disseminating Surface Observations

AT THIS POINT in the course, you have studied considerable information about making that diversified and highly perishable product called a weather observation. You have reviewed the product in the general terms of weather systems and meteorological principles, and progressed to the specifics of observing, identifying, and recording the many individual elements involved. You have studied the mathematical operations involved in deriving data. You have reviewed the use of the various instruments and equipment that help you measure weather elements. You need this information to observe the many weather elements, correlate the data that you obtain, and record the observation on AWS Form 10 in a definite format. As you have probably guessed by now, this format was devised to meet two needs: speed and standardization.

2. Speed in encoding and recording observations has always been important. You can take a greater number of observations per unit of time in symbolic shorthand than you could if you had to write out the observation entirely. The symbol "−X" is considerably easier and quicker to write down than the condition it represents—"partly obscured condition." Those who devised weather reporting codes were quite aware that a method of reporting must be both rapid and universally understood. This is just as obvious now as it was then. You have to be brief, yet clear.

3. To facilitate clarity and understanding, standard symbols were devised to represent sky cover and weather elements. Rules were established for reporting numerical values, and a definite sequence for reporting data was established.

4. The brevity of airways encoding creates the need for accuracy in recording and subsequently disseminating an observation. Erroneously reporting an aircraft ceiling as A2⊕ when it is actually A20⊕ can easily affect aircraft operations, since the first report borders upon instrument flight rule (IFR) minimum conditions and the second report represents visual flight rule (VFR) conditions. If you omit a figure in the report, it can change the report significantly. It is obvious that if you report the visibility as "1½" when it is "½," aircraft operations will be affected by the erroneous insertion of the extra figure.

5. This chapter has two sections. The first section discusses in detail the encoding of surface observations and pilot reports that are usually handled in the weather unit. The second section discusses the dissemination of weather data and the different processing and display procedures involving teletype data, facsimile charts, RAREPs, and satellite charts.

10. Types of Observations

10-1. In Chapter 1 of this volume you learned how to enter your observations correctly on AWS Form 10. Now you will study the types of observations and the coded format required when established observing criteria are met. We will answer such questions as when should you take and record a special observation? What columns are encoded for a special observation? What do you do if your observation becomes invalid before you can disseminate it? These questions are the primary concern of this section.

10-2. Before you examine each type of surface observation and its proper code format, you should know that with a few exceptions an airways code report includes two things. First, it includes the station call letters (provided by teletype circuit operations in most cases). The call sign for reporting stations is always indicated by a three-letter designator for areas within the United States. Second, an airways code report includes the entries in columns 3 through 13 of Form 10 except for the column 13 data in parentheses. Even though other Form 10 columns are necessary for the completion of all observations, we are discussing here only those columns that are actually used to make up airways reports. For example, column 1, type of observations, is not a part of the airways code. Column 17, though used to obtain sea-level pressure and altimeter setting values, is also not part of the code.

10-3. The airways code is derived from the order (sequence) of entries of the individual elements on Form 10. Therefore, the *airways code follows the same pattern as the recorded observation.* The coded form differs only in the method of indicating element separation. All airways code reports are classified into three basic types: *record, special,* and *local* observations.

10-4. **Record Observation.** Record observations are frequently referred to as hourly, 3-hourly, and 6-hourly observations. Record airways code reports are scheduled for hourly transmission over longline communications circuits. Since the observation is transmitted on the hour, you should start each record observation before the hour, allowing sufficient time to encode and disseminate the observation over teletype. Usually, you should observe all elements of the observation within 15 minutes preceding the time of dissemination. This means that if you complete your record observation 2 to 5 minutes before the hour, no element should be observed more than 15 minutes before the actual time of the observation. Of course, this is only applicable to the elements that you observe and not to elements you append to your observation, such as pilot report data and similar additions from other sources. Let's examine the encoding procedures for hourly record observations.

10-5. Encoded hourly airways observations use the following Form 10 column entries:

a. Column 3, Sky Condition.
b. Column 4, Prevailing Visibility.
c. Column 5, Weather and Obstructions to Vision (when applicable).
d. Column 7, Temperature.
e. Column 8, Dewpoint.
f. Column 9, Wind Direction.
g. Column 10, Wind Speed.
h. Column 11, Wind Character (when applicable).
i. Column 12, Altimeter Setting.
j. Column 13, Remarks as appropriate.

10-6. Hourly airways code observations differ from 3- and 6-hourly observations in two ways. First, no sea-level pressure (column 6) is encoded for hourly observations, and second, column 13 entries for hourly observations are restricted to the following data:

a. RVR or RVV.
b. Obscuring phenomena.
c. Wind shifts.
d. Magnetic wind (selected stations only).
e. Bases and tops of layers.
f. All other remarks pertaining to previously coded elements.
g. RADAT or RAICG (when available).
h. Runway conditions.
i. RIII group (1600 GMT hourly only, when scheduled).

Naturally, it is a rare situation when even half of these entries are entered on a single hourly record observation.

10-7. In the earlier discussion of surface observations (Chapter 1), you learned the way to make entries in each column of Form 10. However, you do have a problem in knowing which column and supplemental data entries are necessary for a particular observation. The preceding pragraphs list all entries that make up an hourly airways observation. Examine foldout 4 to see whether or not the hourly observations contain the required data.

10-8. Notice how simple it is to encode airways reports—you only need to know which columns and data make up an observation and when to begin an observation. Let's examine two hourly airways reports from foldout 4 and see how they appear in the final coded form. The observation at 0656 LST is encoded as:

FWR ○ 71/65/1713G19/979/AC NE

10-9. Notice the way that the data is taken from the Form 10 entries. There is a space between the station call letters (FWR) and the sky condition (○) and also between the visibility (10) and the temperature (71) elements. The temperature, dewpoint, winds, and altimeter setting are separated by slants. The spacing is better illustrated by the way the 1256 observation is encoded into airways code.

FWR 15⦶25⦶R36⊕21/2TRWA 72/71/2218G36/
974/RCD⊕450/ T N–E–S AND OVHD
MOVG E FQT LTGICCC N–E–S A B56
HLSTO 1/4 VSBY E1 PK WND 22/36 54

10-10. This example shows the correct format when you have numerous entries. There is the standard space between the call letters and the sky data and between the weather and temperature data. Slants separate each column entry except those entries that all pertain to one element, such as the wind. The column 13 remarks are added in the prescribed order as listed in paragraph 10-5. This example shows a Radar Cloud Detection Report (RCD) remark which has priority over the succeeding remarks. Notice that following the RCD remark, all other remarks are entered without regard for any specific order. This enables you to encode all remarks as you observe them, rather than waste valuable time arranging them in a certain order, or possibly omitting them. The main concern is that you encode all operationally significant remarks as listed in FMH–1, and any additional remarks if you think they contribute to the observation.

10-11. Hourly record observations combined with 3- and 6-hourly observations enable interested agencies to have an airways report for each

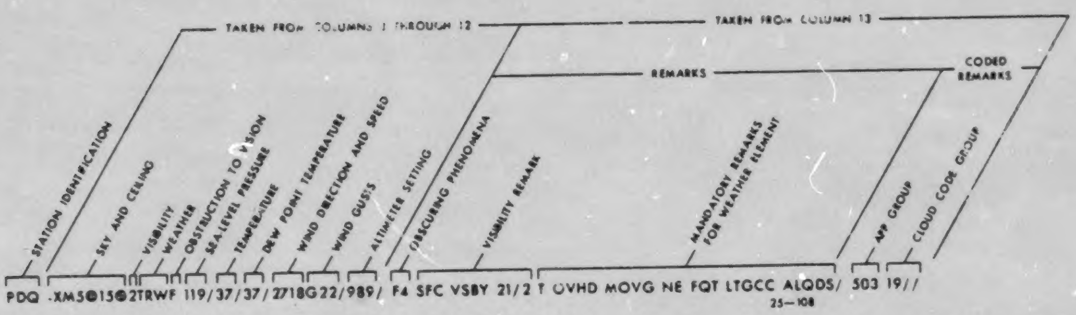

TAKEN FROM COLUMNS 1 THROUGH 12
TAKEN FROM COLUMN 13
REMARKS
CODED REMARKS
STATION IDENTIFICATION
SKY AND CEILING
VISIBILITY
WEATHER
OBSTRUCTION TO VISION
SEA-LEVEL PRESSURE
TEMPERATURE
DEW POINT TEMPERATURE
WIND DIRECTION AND SPEED
WIND GUSTS
ALTIMETER SETTING
OBSCURING PHENOMENA
VISIBILITY REMARK
MANDATORY REMARKS FOR WEATHER ELEMENT
APP GROUP
CLOUD CODE GROUP
PDQ -XM5⊕15⊕2TRWF 119/37/37/2718G22/989/ F4 SFC VSBY 21/2 T OVHD MOVG NE FQT LTGCC ALQDS/ 503 19//
25—108

Figure 20. Example of coded 3-hourly record observation (airways code).

hour of the day. The 3-hourly observations are recorded at 0300, 0900, 1500, and 2100 GMT. The 6-hourly observations are recorded at 0000, 0600, 1200, and 1800 GMT.

10-12. The 3-hourly observation is encoded the same as hourlies except that you must include certain data and coded groups as follows:

a. Sea-level pressure (column 6)
b. app
c. $1C_LC_MC_H$ (when clouds are present)

10-13. Foldout 4 shows examples (four per day) of 3-hourly observations. To encode these observations, follow the same rules that you use for hourlies except that you include the sea-level pressure and the coded additional data groups. Figure 20 is an example of a 3-hourly observation and shows the way that each element is arranged in code. Notice that there is a separation between obstructions to vision and the sea-level pressure and that the coded data is separated from the remarks by a slant.

10-14. The 6-hourly observation is the remaining type of record observation taken at a weather station. This record observation type differs from 3-hourly airways code observation only in the instructions for column 13 coded data entries. For a 6-hourly, these entries are:

a. appRR
b. $1C_LC_MC_H$
c. 904spsp (when applicable)
d. $T_{n/x}T_{n/x}$ (when required)
e. $2R_{24}R_{24}R_{24}R_{24}$ (1200 GMT only)

10-15. Foldout 4 shows four examples of 6-hourly record observations. The observation at 1155 LST appears in coded form as:

FWR M42⦶80⊕15 081/86/58/1808/977/CB SSW–
W MOVG NE TCU ALQDS RWU SW
BINOVC/ 703 197/ 61

10-16. As you can see, record observations require few special instructions if you have entered the data on Form 10 correctly. One of your main concerns is to complete each record observation in the desired time period (2–5 minutes before the hour). This is especially important when your observation elements are analyzed with surrounding stations on a weather map. Elements of your observation that are taken unnecessarily early often result in an unreliable analysis. This is one reason why you should read the barometer (last element to be observed) as close to the hour as possible. Let's take the case of a frontal zone near your station. Suppose a nearby station reads its barometer 10 minutes earlier than you. When a fast-moving cold front is present in the area, this could cause an erroneous analysis of the speed at which the front is moving. When elements of your observation change significantly during the time period between record observations, you should take and encode a special observation. The requirements for a special observation are given in the following paragraphs.

10-17. **Special Observation.** FMH–1 lists the criteria for taking special observations. We will give you these important criteria and show you the way special observations are taken whenever operationally significant conditions are present. You must know what meteorological situations are critical at your station. For example, an airbase whose operations involve departures of fighter aircraft almost exclusively has meteorological interests different from those of a base whose mission is to provide transport service for overseas areas.

10-18. Encoded special airways observations use the following Form 10 entries:

a. Column 2, Time (convert to GMT).
b. Column 3, Sky Condition.
c. Column 4, Prevailing Visibility.
d. Column 5, Weather and Obstructions to Vision (when applicable).
e. Column 9, Wind Direction.
f. Column 10, Wind Speed.
g. Column 11, Wind Character (when applicable).
h. Column 12, Altimeter Setting.
i. Column 13, Remarks.
(1) RVR or RVV.

(2) Obscuring phenomena.
(3) WSHFTS.
(4) MAG wind (selected stations only).
(5) MSL bases and tops of layers.
(6) Remarks pertaining to preceding coded elements.
(7) Runway condition reading (RCR) remark.

10-19. Naturally, these elements represent the *maximum* number of entries made on a single special observation. To better understand the encoding of special observations, let's examine the mandatory criteria for encoding special observations.

10-20. *Ceiling and sky condition.* Take special observations within 15 minutes after you return to duty following a break in the hourly observation schedule. Also take special observations for ceiling and sky condition when:

a. The ceiling forms below, decreases to less than, or, if below, increases to equal or exceed:

(1) 3,000 feet.
(2) 1,000 feet.
(3) 500 feet.
(4) All nationally published minima, applicable to the airport, listed in the Coast and Geodetic Survey (C&GS) Instrument Approach Procedure Charts or Department of Defense Flight Information Publications (DOD FLIPs).
(5) Values established locally because of their significance to aircraft operations.

b. Clouds or obscuring phenomena aloft are present below:

(1) 1,000 feet and no layer was reported below 1,000 feet in the preceding "R," "S," or "RS" observation.
(2) The highest published instrument minimum applicable to the airfield, and no sky cover was reported below this height in the previous "R," "S," or "RS" observation.

10-21. *Prevailing visibility.* Take special observations for prevailing visibility when the visibility decreases to less than, or, if below, increases to equal or exceed:

a. 3 miles.
b. 2 miles.
c. 1½ miles.
d. 1 mile.
e. All nationally published minima, applicable to the airport, listed in the Coast and Geodetic Survey (C&GS) Instrument Approach Procedures Charts or Department of Defense Flight Information Publications (DOD FLIPs).
f. Values established locally because of their significance to aircraft operations.

10-22. *Runway visual range.* Take special observations for runway visual range when the 10-minute mean RVR decreases to less than, or if below, increases to equal or exceed each nationally published minima applicable to the runway in use.

10-23. *Tornado, funnel cloud, waterspout, and thunderstorm.*

a. Take special observations when a tornado, funnel cloud, or waterspout:

(1) Is observed.
(2) Disappears from sight.
(3) Occurs within the past 6 hours and is reported by outside sources but has not been observed or recorded at the station.

b. Take special observations when a thunderstorm:

(1) Begins (a special is not required to report the beginning of a new thunderstorm if one is currently reported as in progress at the station).
(2) Increases in intensity (T to T +).
(3) Ends (remember, a thunderstorm has not ended until 15 minutes after thunder was last heard.)

10-24. *Precipitation, wind, and wind shifts.*

a. Take special observations for the different types of precipitation when the following occurs:

(1) Hail begins or ends.
(2) Freezing precipitation begins, ends, or changes in intensity.
(3) Ice pellets begin, end, or change intensity.
(4) Precipitation (other than very light) begins or ends.

b. Take a special observation for *wind speed* when the average 1-minute wind speed suddenly increases to twice, or more than twice, the currently reported 1-minute wind speed and exceeds 26 knots.

c. Take a special observation for a *wind shift* when the wind direction changes 45° or more, and takes place in less than 15 minutes.

10-25. Special observations for these severe weather occurrences may be reported as a *single-element special observation.* This means that you only need to transmit the time of the observation and the appropriate remark. For example,

FWR 1131Z UNCONFIRMED TORNADO 20 W
FWR MOVG E1112

Single element special observations are also authorized for reporting runway conditions. For example, for packed snow on the runway, decelerometer reading 15 is encoded PSR 15.

10-26. Presently, these are the requirements for taking special observations. There are, however, many other meteorological situations which you may think are significant to aircraft operations and which you should take as a special observation. Foldout 4 shows examples of both mandatory specials and operationally significant specials. For example, at the 0111 LST special, the observer reported the presence of a 2/10 partly obscured sky condition which lowered the visibility to 3 miles. Again, for the special at 0235 LST, the observer felt that changes in the ceiling height and visibility were operationally significant. Foldout 4 also shows several examples of special observations occurring at record observation times.

10-27. **Local Observation.** Local observations may be taken and recorded at any weather observing station. Local observations are recorded only on Form 10 at Air Force stations that do not have a permanent printed record of each observation (Electrowriter, etc.). With the exception of local observations taken for an "aircraft mishap," local observations include one or more elements but usually include the following:

a. Time.
b. Sky condition.
c. Prevailing visibility.
d. Weather and obstructions to vision (when applicable).
e. Altimeter setting.
f. Remarks, as appropriate.

10-28. Local policy generally prescribes meteorological conditions that require local observations at the station. Local observations are also taken for the following required (FMH-1) conditions. When these conditions exist, local observations should be:

a. Taken and recorded immediately following notification of an aircraft mishap occurring at or near the station unless there has been an intervening record or record special observation. Such observations consist of all elements normally included in a record observation except sea-level pressure and are identified in remarks as "ACFT MISHAP," plus any other desirable explanatory material. If the report is disseminated, the remark "ACFT MISHAP" is not included. An "ACFT MISHAP" local observation need not be recorded for inflight emergencies, i.e., those declared to reflect an unsafe condition which could adversely affect the safety of the aircraft. However, such inflight emergencies should alert the observer to intensify the weather watch and to take and disseminate weather data as necessary to insure maximum support to the aircraft in distress. If the inflight emergency results in an accident or incident, the "ACFT MISHAP" local observation is then required.

b. Taken following notification of a change in the runway in use. If the runway is dually instrumented, change weather sensors and allow sufficient time to update with current information before taking the observation. Include the following elements in this observation:

(1) Time.
(2) Ceiling and sky.
(3) Weather and obstructions to vision.
(4) Wind direction, speed, and character.
(5) Altimeter setting.
(6) Remarks, as appropriate.

This observation is not required if the station has single instrumentation which is installed nearer the midpoint than the end of the runway, or if the station does not have ceiling, visibility, or wind equipment installed on any runway.

c. Taken at stations required to report RVV or 1-minute mean RVR and:

(1) Criteria for taking RVR or RVV observations are first met, and when the criteria are first noted to no longer exist.

(2) RVR or RVV decreases to less than, or (if below) increases to equal or exceed, each RVV or RVR minima applicable to the runway in use.

(3) Rnn(d)VVNO or 1MRnn(d)VRNO is first required to be reported for the runway in use, and when it is first determined that the contraction is no longer applicable, provided conditions for reporting RVV or RVR exist.

d. Taken and disseminated for altimeter settings.

(1) When necessary to meet local requirements, which are determined locally through coordination with using agencies.

(2) Upon request.

(3) At a frequency not to exceed 35 minutes since the last determination.

10-29. An exception to the requirement of *d*(3) above is granted at locations where there is limited air traffic, no air traffic control personnel on duty etc., provided:

a. The base commander and local agencies concerned agree in writing (the agreement must be reconfirmed annually and when signatories are reassigned).

b. Firm procedures are established to insure that the observer is notified at least 30 minutes prior to each aircraft arrival and departure, and

c. The altimeter setting is redetermined within 30 minutes prior to all aircraft arrivals and departures.

At locations where the local dissemination device does not provide a printed record, local observations which contain only an altimeter setting need not be recorded on AWS Form 10, providing the altimeter is recorded in the Remarks section of AWS Form 40, Local Dissemination Log.

10-30. Since local observations are normally entered only on the Electrowriter or a similar communications device, the proper encoding format is shown in Volume 3. In addition to correctly encoding your surface observations in the proper format, you are also responsible for encoding pilot reports, which is our next subject.

10-31. **Pilot Reports.** Suppose an aircraft departs another airbase at 1115 LST time and lands at your airbase, 400 miles away, at 1330 LST. The aircraft commander tells the duty forecaster that he was flying a C-47 at 10,000 feet and that he experienced light to moderate turbulence during the entire flight. He also says that there is a line of building cumulonimbus clouds 35 miles west of the station. What is the value of this report?

10-32. Reports such as this alert the forecaster to areas of actual turbulence. Pilot reports provide information that, generally, cannot be obtained from other sources. These reports also identify significant phenomena in the areas between reporting stations.

10-33. Your job in handling pilot reports is to insure that each pilot report is encoded correctly and that it receives the proper dissemination. This requires that you know the types of phenomena that are commonly reported and the way that each element is arranged. The first coded elements of any pilot report are the location and the time of observation.

10-34. *Location and time.* The location or extent of phenomena and the observation time are very important parts of the encoded pilot report. Following your station call letters and the contraction "PIREP," each coded report begins with the location or extent of phenomena. This element of PIREP code is reported as the location of the phenomenon relative to your station or another nationally known point. For example, the location (extent) of a line of thunderstorms can be reported as "20NE BLV-75WSW RAN." Another example of expressing the existence of a given phenomenon along a flight route is to give the departure and destination points, such as "GUS-LCK," which indicates that the occurrence is almost continuous between Grissom AFB and Lockborne AFB. All distances are given in nautical miles except visibility, which is expressed in statute miles.

10-35. When entered in its proper position, the location appears as:

RAN PIREP 30NW RAN
RAN PIREP RAN-SGF
RAN PIREP OVR DEN
RAN PIREP 30NE STL-STL

These are four typical examples of the first coded element of a PIREP which is the location. Immediately following this element, you enter the time of observation.

10-36. Sometimes when pilot reports are received either by radio communications or personally from the pilot, the time of the actual observation is confused with other times. For example, while in flight, a pilot reports a thunderstorm that he observed 20 minutes ago. After some additional delay, the report reaches you; the only time you receive is the time of the pilot's report—20 minutes after the storm occurred—and the report you receive may not indicate that the thunderstorm occurred 20 minutes before the pilot's report. Whether the forecaster, control tower personnel, or you receive the pilot report, make every effort to determine the actual time of observation. You may have to ask the pilot specifically what time he observed the phenomenon if you are unsure.

10-37. Encode the time of observation to the nearest whole minute GMT, following the location or extent of phenomena. For example,

RAN PIREP 30NW RAN 1131
RAN PIREP RAN-SGF 1115-1316

10-38. The second example of an observation time (1115-1316) represents a situation in which the pilot reports phenomena along a route (RAN-SGF); these times indicate that the pilot started his observation at 1115 (over RAN) and ended it at 1316 GMT (over SGF). This method of reporting observation times for point-to-point reports is better than using only one time. This gives the people who interpret the data a much better idea of the time that the phenomenon actually occurred along the route. When you have correctly identified these elements in the coded PIREP, enter the text (type of phenomena) of the report.

10-39. *Types of phenomena.* This portion of the PIREP code contains the actual meteorological occurrences that the pilot is reporting. Your job is to enter these phenomena, using accepted weather symbols, contractions, and plain language, in a format that is easily understood. Before examining some common entries, let's discuss some general rules that pertain to encoding PIREP phenomena and associated elements.

a. Encode the heights (altitudes) in the PIREP in hundreds of feet MSL. This is no major problem because pilots report heights in feet MSL. The main thing to remember is not to convert these heights to the reportable values that you use in column 3 of Form 10.

b. Another general rule is to identify each element by an authorized weather and intensity symbol when possible (thunderstorm = T, heavy rainshower = RW +). For cloud types, use the international cloud abbreviations (cumulus = CU, cumulonimbus = CB).

c. When a pilot reports a phenomenon that cannot be explained with a standard symbol or abbreviation, use the meteorological contractions listed in the FAA *Contraction Manual* to explain the phenomenon. If you cannot find a suitable contraction or if the contraction could be misinterpreted, use plain language to explain the situation. For pilot reports of hazardous weather, use plain language remarks as required.

10-40. *Hazardous weather.* Hazardous weather conditions are considered phenomena which present an immediate danger to life and property, whether at the earth's surface or in the atmosphere. Some examples are hail, tornadoes, funnel clouds, waterspouts, thunderstorms, widespread duststorms or sandstorms in which the visibility is reduced to less than 2 miles, and lines of cumulonimbus clouds (squall lines) that are capable of producing severe weather. Encode the more severe forms of these phenomena in plain language and the associated elements in standard contractions, if possible. For example,

```
TOP PIREP 20W MKC 1215 TWO FUNNEL
    CLOUDS SIGHTED MOVG E
AMA PIREP 40W AMA-75E ELP 1347 WDSPR
    SANDSTORM VSBY RSTRD TO 1/2 MI
```

10-41. These two PIREPs show how hazardous weather is encoded in both plain language and contractions. The idea is to encode the data in a concise but clear manner. In the second PIREP, sandstorm is entered in plan language to insure that it is not mistaken for other data or overlooked. The other contractions are standard meteorological contractions that are commonly used by personnel associated with flying operations.

10-42. Use symbols and intensity signs if the hazardous weather phenomena can be encoded without their being mistaken for other entries. Notice the following typical examples:

```
RAN PIREP HUF-10W EVV 1538-1601 LN T+
    TOPS 370-400
RAN PIREP 15W SPI 1735 LRG CB TOPS 370
RAN PIREP 15W RAN 1600 RW + HAIL 60 CB
    DSNT W
```

10-43. In these examples, you can see that you must determine the order of entry for each element, using your judgment as the guide. Each weather symbol used in these examples is easily understood. Notice that by listing the heights after the type of phenomena, the location is further identified. In the PIREP that contains heavy rainshowers and hail (RW+ HAIL), the height 6,000 feet (60) explains the level at which the pilot experienced or sighted this phenomenon. Some phenomena observed by pilots in flight present no hazard to people or objects on the earth's surface, but do pose a serious threat to flight operations. These types require special encoding procedures.

10-44. *Turbulence.* All aircraft have structural limits. Turbulence is an atmospheric condition that not only taxes these structural limitations but tends to disrupt the aerodynamic forces that are essential for flight. One form of turbulence is associated with convective cloud forms. Because they are a definite hazard to them, pilots are trained to avoid these areas of turbulence near convective clouds. Another type of turbulence, clear air turbulence (CAT), poses a greater threat to the pilot because it or the conditions causing it cannot be seen. The pilot has no warning [illegible] where it exists and the encoding of CAT reports has special significance to all agencies involved in flight operations.

10-45. There are four standard contractions for turbulence intensities:

LGT (light)
MDT (moderate)
SVR (severe)
EXTRM (extreme)

The term "TURB" for turbulence is entered immediately following the intensity when the turbulence is not associated with clear air. When the pilot reports turbulence but indicates that he was in the "clear," enter the contraction "CAT" following the intensity instead of "TURB." For example, moderate turbulence over Chanute AFB (Rantoul) at 1202 GMT and moderate clear air turbulence over Topeka at 1132 GTM are encoded as:

```
RAN PIREP OVR RAN 1202 MDT TURB
RAN PIREP OVR TOP 1132 MDT CAT
```

10-46. Does this report indicate that "CAT" is present over Topeka? Yes, but at what level? Moderate turbulence for what—a fighter aircraft or bomber, such as the B-52? As with other hazardous phenomena, turbulence requires an altitude at which the turbulence was experienced; for example, MDT CAT 70-80.

10-47. Each PIREP containing a report of turbulence must have either the aircraft type included with the coded data or the remark "ACFT UNK." Without the type of aircraft, the forecaster or pilots cannot fully evaluate the intensity of the turbulence. A large transport aircraft may report no turbulence, but does this mean that a smaller craft will not experience turbulence?

10-48. This is why many pilots report the absence of turbulence and their aircraft type so that their report can be fully evaluated. Surely other pilots want to know areas that are free from turbulence as well as the "turbulent" areas. For this situation, enter the remark "NEG TURB" followed by the altitude and aircraft type.

10-49. *Icing.* Icing is another phenomenon that alters or influences the aerodynamic forces which act upon an aircraft. Icing is encoded in PIREP format similar to turbulence entries. The intensities of icing are shown below:

TRACE (trace)
LGT (light)
MDT (moderate)
HVY (heavy)

10-50. There are two basic types of icing—rime (RIME) and clear (CLR). When both rime and clear icing conditions are encountered, the pilot reports this icing as *mixed* (MXD). The type of icing follows the intensity in the PIREP format. The contraction "ICG" for icing is entered after the type of icing. For example, a pilot flying a C-5A reports that he is experiencing heavy clear icing at 6,500 feet MSL. Encode this as:

HVY CLR ICG 65 C-5A

10-51. To make this a complete report, add the term "PIREP," the location or extent of the phenomenon, and the time of observation. As shown in the example, you should show the altitude of icing (65) and the aircraft type (C-5A) just as you do for turbulence. The aircraft type is required on all reports of icing or turbulence. In addition to turbulence and icing, PIREPs often contain bases and tops of sky cover.

10-52. *Sky cover.* Encoding sky cover data (bases and tops) in PIREP form is an easy task. Just apply the same rules that are discussed in Chapter 1 for pilot report data. For example, use appropriate sky cover symbols, if possible, and encode the bases or tops of each layer in hundreds of feet MSL. Suppose that a pilot reports cloud layers at 4,000 scattered; 6,800 broken with tops at 7,500; a layer at 30,000 amount unknown. These data are encoded in PIREP form as:

40⦶ 68⦷75 300 U

10-53. *Thunderstorm.* Encoding thunderstorms is also very similar to encoding them for the Remarks section on Form 10, as discussed in Chapter 1, for example. If a pilot reports a broken line of thunderstorms 30 miles south through west of Rantoul with bases at 3,500 and tops at 40,000 with occasional lightning in the clouds, these data are encoded in PIREP form as:

LN TSTMS 30 MI S-W RAN 35⦷400
OCNL LTGIC

10-54. Since thunderstorms usually cause such extreme conditions, you may receive some other common types of phenomena. Some of the more common are:

- Electrical discharge.
- Temperatures (extreme).
- Winds aloft (strong).
- Condensation trails.

10-55. Electrical discharges are reported by an aircraft when they actually strike the aircraft in flight. This is encoded in the PIREP as "DISCHARGE" followed by the altitude and type of aircraft.

10-56. Temperatures are encoded in PIREP code form by the contraction "TEMP" followed by the actual temperature in degrees Celsius. The procedures for encoding temperature data in the PIREP form vary somewhat. Three common ways to encode a temperature of −14°C at 6,000 feet are as follows:

TEMP −14 60
TEMP MS 14 60
TEMP MINUS 14 60

Though the last example for encoding temperature data is used by some stations, the first two examples are the recommended entries for PIREP code.

10-57. Winds aloft reports are indicated by the contraction "WND." Follow this contraction with the *true* direction from which the wind is blowing (290 = 290°) to the nearest 10° and the speed to the nearest knot, such as:

WND 270 35 KT 70
or
WND 270/35 70

These examples show the two most common methods of encoding wind data for a PIREP. In both examples, the wind reported by the pilot is at 7,000 feet MSL from 270° at 35 knots.

10-58. Condensation trails are indicated in PIREP form by the contraction "CONTRAILS" followed by the altitude and the aircraft type, such as:

CONTRAILS 450 F111

In addition to turbulence, icing, and electrical discharges, contrails are the only other phenomena which require that the aircraft type be included with the report.

10-59. Pilot reports which contain hazardous weather phenomena need to be given immediate local dissemination and transmitted longline as weather warning bulletins. These phenomena are:

- Tornadic activity.
- Severe or extreme turbulence.
- Hail.
- Severe icing.

10-60. As indicated earlier, pilot reports do not necessarily follow a standard format. Certain phenomena or situations that the pilot observes require the use of contractions or plain language that we have not discussed in this chapter. We have shown you the most common types of phenomena that are reported by pilots and the way to encode this data in PIREP format. AWS units are required to enter all useful pilot reports on AWS Form 12, *Pilot Report Form*. This form not only aids in the encoding of PIREPs but also provides information on the proper use and dissemination of PIREPs.

10-61. **AWS Form 12 Entries.** This form is easy to complete and is a written record of the report. Figure 21 is a sample pilot report for longline dissemination in PIREP form. Extract the elements as previously discussed and prefix your station call letters to the report. When encoded, the PIREP in figure 21 appears as:

BLV PIREP 10NE BLV 1443 TRW ALWDS LGT
TURB 90 T-29

10-62. When a problem that is not explained arises in regard to entering pilot report data on AWS Form 12, let your judgment prevail. Remember, the primary concern is to have a report that can be used effectively. The forecaster knows which PIREPs are important meteorologically, and when he is on duty, he is required to review each PIREP before its transmission. PIREPs that you can include with your airways observation will eliminate the need for making separate transmissions.

10-63. Encoding airways and PIREP code forms is an everyday task for most observers. Also, a routine task is disseminating and processing weather data. We will discuss disseminating and processing weather data in the next section.

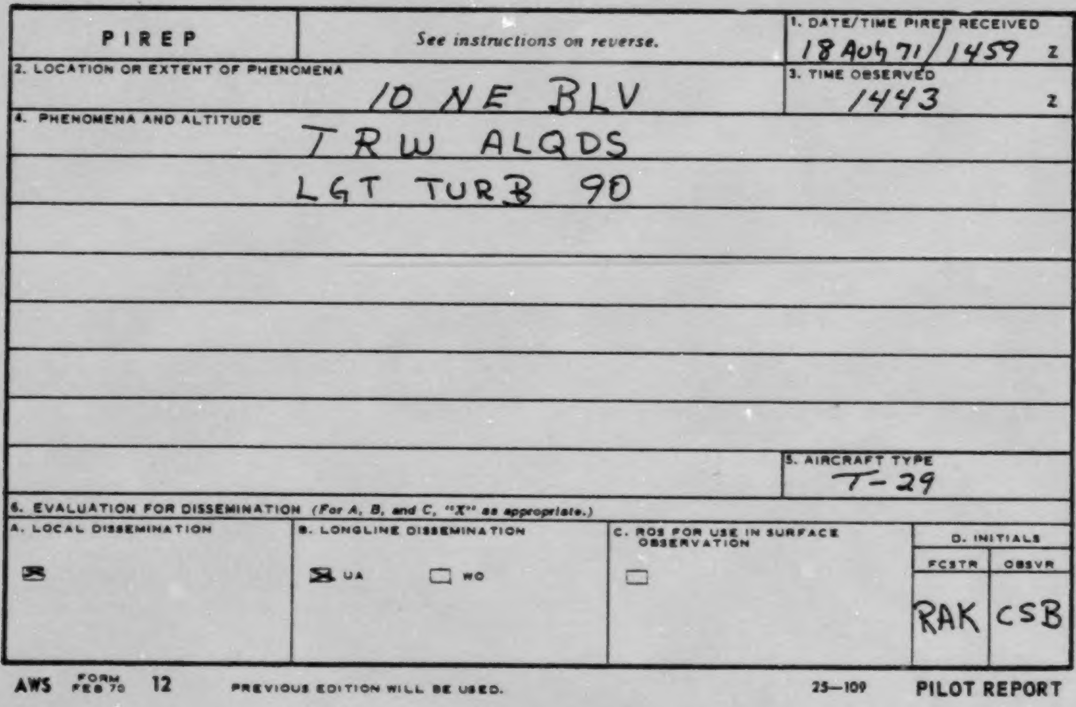
10-64. Before proceeding further, refer to the chapter review exercises in the Workbook and answer the questions for Section 10.

11. Disseminating and Processing Weather Data

11-1. In Volume 1, Section 10, we covered the various types of communications and copying equipment such as:

- Autographic transcribers.
- Intercommunication systems (INTERCOM)
- Telephone.
- Tape recording devices.
- Pony circuit.
- Weathervision.

In this section we explain the techniques used to disseminate weather data by autographic transcribers and intercommunications systems. Also, we will explain the steps in processing and displaying weather data received from the various types of equipment.



PIREP

See instructions on reverse.

1. DATE/TIME PIREP RECEIVED 18 Aug 71/1459 Z

2. LOCATION OR EXTENT OF PHENOMENA 10 NE BLV

3. TIME OBSERVED 1443 Z

4. PHENOMENA AND ALTITUDE
TRW ALQDS
LGT TURB 90

5. AIRCRAFT TYPE T-29

6. EVALUATION FOR DISSEMINATION *(For A, B, and C, "X" as appropriate.)*

A. LOCAL DISSEMINATION ☒

B. LONGLINE DISSEMINATION ☒ UA ☐ WO

C. RQS FOR USE IN SURFACE OBSERVATION ☐

D. INITIALS FCSTR RAK OBSVR CSB

AWS FORM FEB 70 12 PREVIOUS EDITION WILL BE USED. 25—109 PILOT REPORT

Figure 21. Sample pilot report form.

11-2. **Local Dissemination.** Since your primary concern when working in the ROS is the weather conditions in the vicinity of your base, it is important to furnish all operationally important reports in your station's local area to the weather station, base operations, control tower, GCA units, other airgound communications sites, and as many other local interests (squadron operations, etc.) that desire them. These reports are disseminated locally by the equipment covered in the following paragraphs.

11-3. *Autographic transcription.* As stated in Volume 1, Section 10, there are several types of autographic transcribers used at weather units. Many are known by various trade names. The Electrowriter and Telautograph are very common to the weather station because of their ability to copy any form of writing and symbols.

11-4. Regardless of the type of equipment you use to disseminate your observations, your unit will have a standard procedure established to disseminate your data. This standard format will be based on the FMH-1 required entries, and usually follows across AWS Form 10 from column 1 through 13. The following is an example of how your dissemination procedures may be outlined (detachment operating instructions) in your weather unit:

DISSEMINATION PROCEDURES

1. Space all entries on the T/A evenly and write large enough to make for easy reading (use block letters).
2. Six mandatory requirements for each transmission, except for testing are:
   - *a.* Identity of station (RAN).
   - *b.* Identity of transmission by type (R, RS, S, L, PIREP, etc.)
   - *c.* Day/time (ZULU) of the observation, (16/1456Z).
   - *d.* Message content. Form 10 entries: Column 1 through 13 except SLP; omit 3- & 6-hourly additive data.
   - *e.* Actual time of transmission in hours and minutes, (1457Z).
   - *f.* Initials of person making transmission, (CB).
3. Use the following in placing data on the transcriber.
   - *a.* Clear sky—use CLEAR.
   - *b.* Wind.
     - (1) Calm—use CALM.
     - (2) Direction, magnetic only to nearest 10 degrees in 2 digits.
     - (3) Speed, in 2 digits.
     - (4) Example: 0309.
   - *c.* Altimeter, in 4 digits and flag all altimeter settings with ALSTG—ALSTG 3002.
   - *d.* The contraction "ACFT MISHAP" is *never* disseminated over the transcriber.
4. Example:

```
RAN R  16/1456Z
CLEAR 15 92/66
0309     ALSTG 3002
                1458Z/CB
```

11-5. *Intercommunication system (INTERCOM).* When speaking into an intercom system you should talk at a moderate speed and speak very clearly. As you are establishing your first contact, be sure to identify yourself since there may be more than one unit using the same intercom. For example: THIS IS WEATHER and conclude with the word OVER. After communications have been established, and when confusion is unlikely, go ahead with your report as follows:

a. CLOUDS. State cloud heights in hundreds and/or thousands of feet. Report ceiling classifications as follows:

A as	PILOT REPORTED CEILING
E as	ESTIMATED CEILING
B as	BALLOON CEILING
M or R as	MEASURED CEILING
W as	INDEFINITE CEILING

Partly obscured and obscured conditions:

X or −X as SKY OBSCURED or SKY PARTLY OBSCURED
SKY PARTLY OBSCURED—ESTIMATED CEILING TWO THOUSAND
SKY OBSCURED—INDEFINITE CEILING—VERTICAL VISIBILITY ZERO
SKY OBSCURED—INDEFINITE CEILING—VERTICAL VISIBILITY TWO HUNDRED

b. VISIBILITY. Relay the visibility in statute or nautical miles according to local dissemination policy.

VISIBILITY ONE SIXTEENTH
VISIBILITY THREE QUARTERS
VISIBILITY ONE AND ONE HALF
VISIBILITY FIVE

c. ATMOSPHERIC PHENOMENA and OBSTRUCTIONS TO VISION. Report atmospheric phenomena and obstructions to vision in accordance with FMH-1. Announce the intensity as:

HEAVY, MODERATE, LIGHT, or VERY LIGHT.
VISIBILITY ONE QUARTER FOG
VISIBILITY TWO LIGHT SNOW
VISIBILITY ZERO HEAVY THUNDERSTORMS AND RAIN SHOWERS

d. AIR and DEWPOINT TEMPERATURES. Air and dewpoint temperatures are given in degrees Fahrenheit. Use the words PLUS and MINUS only when reported values are close to zero and are subject to misinterpretation.

TEMPERATURE THREE SEVEN—DEW POINT ONE SIX
TEMPERATURE MINUS ONE—DEW POINT MINUS FIVE

e. WIND. Report the wind direction in tens of degrees using two digits. Magnetic winds are given when reporting local surface conditions and true winds are given when relaying surface observations from other installations and winds aloft; however, identify magnetic winds only when there is a reportable difference between the magnetic and true headings. Report the wind speed in knots by using one or two digits.

WIND MAGNETIC ONE FIVE ZERO DEGREES AT ONE TWO
WIND THREE SIX ZERO DEGREES AT ONE FIVE GUSTING TWO SEVEN
WIND CALM
WIND VARIABLE AT THREE
WIND ZERO SEVEN ZERO DEGREES VARIABLE ONE ONE ZERO DEGREES
WIND ZERO NINER ZERO DEGREES VARIABLE FOUR

f. ALTIMETER. Report the current altimeter setting in four digits.

ALTIMETER TWO NINER EIGHT NINER
ALTIMETER THREE ZERO ONE FIVE
ALTIMETER TWO NINER SIX EIGHT

g. REMARKS. Remarks are relayed in plain language. Report variable ceiling, visibility, and wind conditions as outlined in FMH–1. State sector visibility in the same manner as prevailing visibility.

VISIBILITY TWO VARIABLE FOUR
VISIBILITY NORTH THREE - SOUTH ONE AND ONE HALF

Report amount and type for partly obscured condition as:

SKY PARTLY ABSCURED - FIVE TENTHS SNOW

h. ADDITIONAL PHRASES. Use the following words and phrases as appropriate:

CORRECTION	An error has been made in the transmission (or message indicated). The correct version is . . . .
GO AHEAD	Proceed for your message.
OUT	This conversation is ended and no response is expected.
OVER	My transmission is ended and I expect a response from you.
ROGER	I have received all of your last transmission—to acknowledge receipt; do not use for any other purpose.
STAND BY	I must pause for a few seconds.

11-6. The following is an example of an airways observation as it would be given on the intercom system using the examples listed in paragraphs 11-5.

5⦶M10⦷250⊕3/8F 65/65/2715G30/984/VSBY N 1 1/2

FIVE HUNDRED SCATTERED—MEASURED CEILING ONE THOUSAND BROKEN—TWO FIVE THOUSAND OVERCAST—VISIBILITY THREE EIGHTS—FOG—TEMPERATURE SIX FIVE—DEW POINT SIX FIVE—WIND TWO SEVEN ZERO DEGREES AT ONE FIVE—GUSTING THREE ZERO—ALTIMETER TWO NINER EIGHT FOUR—VISIBILITY NORTH ONE AND ONE HALF—OVER

11-7. Once you complete local dissemination and read back, your next priority is to make the longline transmission with the ADCAD/OWS Weather System. These alphabetical characters are abbreviations for Airways Data Collection and Dissemination and Operational Weather Support Systems. As you may remember from Volume 1, Section 10, the ADCAD teletype system is located in the representive observation site for transmitting observations.

11-8. **Longline Transmission.** Flying safety and the successful achievement of missions demands accurate, up-to-the-minute weather information on a nationwide basis. The ADCAD/OWS system was designed to do this task. The networks are discussed in more detail in Volume 3, Chapter 2. The system consists basically of two paralleling eight-circuit teletypewriter networks. These circuits, operating at 100 words per minute, radiate from the Air Force Weather Relay Facility, Carswell AFB, Texas, to points throughout the United States.

11-9. To assure maximum circuit utilization and the orderly collection and dissemination of regular and special category weather information, a special "programmer" was designed. Basically, the programmer will:

a. Sequentially scan each station on each circuit for regular or special category traffic.

b. Automatically interconnect (switch) circuits of the ADCAD and OWS networks in various predetermined combinations during the period reserved for hourly collections. When the programmer sends out a code to a specific station, the equipment automatically transmits to the line. Each circuit could be compared to a "party line"; that is, when one station transmits, the weather data is copied by all other stations on the line. With these ideas in mind, let's take a look at the types of weather messages that contribute to the overall weather communications transmission.

11-10. *H-Time messages.* "H-Time" messages (polling cycles) are the automatic scanning of the programmer to collect hourly observations. This is done by the ADCAD/OWS programmer transmitting the station's Transmitter Start Code (TSC), which causes the ADCAD-outstation code generator to generate the system Start Of Message Code

(SOM). With your observation tape properly prepared and inserted in the transmitter, your observation is automatically transmitted in proper sequence when your station is scanned by the programmer.

11-11. When the hourlies have all been transmitted on the circuit and your station is assigned, the programmer returns the circuit to "T-Time" polling cycles.

11-12. *T-Time messages.* "T-Time" messages (polling cycles) are for transmitting special observations. When the ADCAD/OWS programmer transmits your station's TSC, your station automatically responds with any special observation you have inserted in the transmitter. During the numerous "T-Time" polling cycles, there will be many instances in which you have no specials to transmit. When this happens, the SPACE answer back code is then automatically generated and sent to the line. It is recognized by the programmer in the Carswell Relay Center monitors, causing it to poll the next station in the polling cycle.

11-13. Meanwhile, your fellow observer working the communications room of the weather station has the Operational Weather Support (OWS) system; this system consists of the 28 Automatic Send/Receive (28 ASR) teletypewriter which was shown and discussed in Volume 1, Section 10. All traffic from the OWS system is sent by the automatic transmitter, which is part of the 28 ASR. Let's take a look at the types of transmissions that are sent from the weather station OWS system.

11-14. *Special category collections.* Certain traffic to be transmitted on the OWS network must be collected during specific polling cycles. To differentiate this traffic from other weather data, it has been designated *special category traffic* (SPs). The time during which SPs are collected varies; they are collected according to published schedules for the system. These schedules are listed in AFSR 105-2, Volume 2, *Weather Communications Operations and Management.*

11-15. The 28 ASR teletypewriter is arranged to transmit five types of SPs. Presently, only two types of traffic have been classified as special category, which are as follows:

Type	*Definition*	*SP Keys*
SDUS	RADAR Storm Detection	SP 1
TAFOR/PLATF	Terminal Forecast Coded/Plain Language	SP 2

At the time that SPs are to be collected, the programmer transmits one of the special two letter codes. This code causes all stations having depressed the corresponding SP button to return to the polling cycle. Conversely, those stations which do not have an SP to transmit will not respond to TSC during the SP polling cycle.

11-16. *Service interruptions.* Whenever your communications services are interrupted on ADCAD COMET I or OWS COMET II (CONUS Meteorological Teletype System), promptly notify your local American Telephone & Telegraph (AT&T) servicing test center (STC). This minimizes the inoperative time. Also, notify the weather relay center of service interruptions; this is done by a TYPNO (contraction used to advise the weather relay facility that the station's communications equipment is out of order).

11-17. For brevity, use operating signals with each TYPNO-TYPOK message. To explain specific deficiencies not covered by the operating signals, you may use plain language. All TYPNO (OK) messages are transmitted over COMET II. Prepare them to provide the following data to the net control center:

- Circuit number of the system affected.
- Description of the interruption.
- MANOP heading of the last message received prior to service interruption or the first message received after restoration of service.

11-18. Transmit all TYPNO (OK) messages to Weather Relay Center at the first available general scan period. Whenever the transmit capability of COMET II is lost, you must telephone your message to a station with a transmit capability. Prompt receipt of service interruption messages from your station allows the center to plan a method of transmitting the missed data to your station when service is restored. Do not assume that the center will announce when a programmer or local channel fails, thereby eliminating your requirement to transmit a TYPNO (OK) message for the outage. Always initiate service interruption messages, because the trouble may be at your station only. Failure to notify the center of teletype outages results in delay of essential data that is missed during the outage period. Now that you have been introduced to the weather communications responsibilities of a weather observer, let's examine some procedures for processing the weather data received via these various communication systems.

11-19. **Processing Weather Data.** While on duty in the weather station you are continually processing weather data of all types. Most of this data is received via communications equipment, such as:

- Teletype.
- Facsimile.
- Radar.
- Satellite.

Your knowledge of the basic procedures involved in processing this data will help you to move on to advanced procedures as you continue to mature as a weather observer.

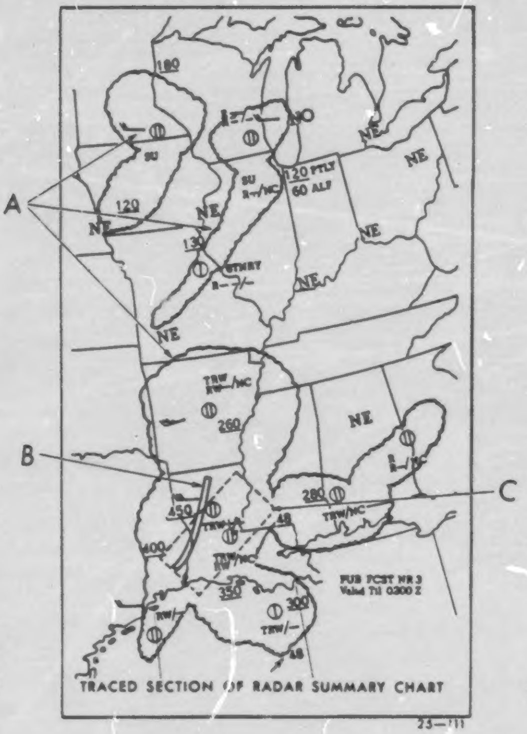


Figure 22. Example of radar summary chart.

11-20. *Teletype data.* Processing teletype data is a task that varies considerably at each station. The reason for the variability is twofold: the amount of space available, and the mission of the base. Each station is arranged individually to satisfy the customers' needs with the space available. For example, the weather requirements at a MAC base will be somewhat different from those for a SAC base. Consequently, the arrangement of the teletype data should be such that it satisfies the requirements for briefing either a MAC or a SAC crew.

11-21. Since your duty assignment requires you to work in the weather station, you will be continually filing and posting the incoming weather messages in their correct place. Knowing all the weather bulletins by their numerical designations and being familiar with the content of each would be asking next to the impossible. There are many people who know most of the bulletins and their contents. This is something that you acquire after years of frequent posting and filing of weather bulletins. It is not necessary at this stage to force yourself to learn the designation of all the weather bulletins. It is helpful to know some of those you frequently use. For example, the mainland of the U.S. is divided into eight separate weather circuits for collection of airways (SAUS) bulletins. In addition, you should learn where to look to find specific information. AWSM 105-2, Volume 1, *Weather Communications,* gives you data type content designators and AWSM 105-2, Volume 2, *Weather Communications,* gives you bulletin contents, etc. In addition to teletype data needing processing, you should be aware of the processing of weather facsimile charts.

11-22. *Facsimile charts.* Facsimile weather maps are a very valuable tool to the forecaster in presenting his briefings to the various aircrews. At many stations, observers are encouraged to color facsimile charts before they are posted in the briefing area. Each local detachment commander determines what processing, how much, and what type of system is used. These rules and systems are explained in AWSM 105-22, *Local Weather Analysis Programs.* Another type of chart you should be familiar with is the radar chart.

11-23. *Radar charts.* Figure 22 is an example of a radar summary chart, which may be colored by the observer before posting in the forecaster's briefing area. The area of echoes (A) is shadowed in yellow, a line of echoes (B) is drawn in red, and an area of severe weather (if any) (C) is drawn in black. Here again, the detachment commander determines how much and what is done to each chart before posting. There is also a new type chart now received in the weather station. It is the satellite chart.

11-24. *Satellite charts.* Recalling Volume 1, Section 10, and figure 60, you'll recall that we discussed a new type recorder used in the weather station. This recorder is used to record satellite charts.

11-25. The TIROS Operational Satellite (TOS) is illustrated in Figure 23. The Advanced Vidicon Camera System (AVCS) equipped satellite provides daily global picture coverages. The Automatic Picture Transmission (APT) equipped satellite provides immediate readout of cloud pictures to suitably equipped ground stations. Both types of satellites travel in circular, sun-synchronous orbits at an altitude of 790 nautical miles. The TOS system will be replaced by the Improved TIROS Operational Satellite (ITOS) System, which will combine stored data and APT, both day and night, in a single earth-stablized vehicle as shown in figure 23. The data are collected at the Command Data Acquisition (CDA) stations. These CDA stations are presently located at Wallops Island, Virginia, and Gilmore Creek, Alaska.

11-26. The National Environmental Satellite Center (NESC) provides the processed data from the CDA station to the Forecast Office Facsimile Networks (FOFAX) to transmit (via telephone lines) to the various stations located on FOFAX NETs. There are three of the networks: GF 10206, 10207, and 10208. These networks are leased from American Telephone and Telegraph

(AT&T) and in turn provide you with the satellite products.

11-27. Processing of these various satellite charts is usually part of the forecaster's function; however, you may be encouraged at some detachments to help process these charts by attaching several charts together to obtain a larger picture and possibly outline the United States and your local state area on the chart in grease pencil. As stated previously, each detachment commander will determine how much and what type of processing is done by the observer before posting the charts in the briefing area.

11-28. Before proceeding to our next subject, Radar Storm Detection Observations, turn to your workbook and complete the chapter review exercises for Section 11.

12. Radar Storm Detection Observations

Radar provides weathermen with a tool which permits the detection of storms and precipitation under conditions when the visual observing methods fail. Taking radar observations involves more than merely turning the radar set on and off. It also involves being able to present a descriptive picture in a standard coded format that all users can interpret. Your progress toward the 5-skill-level AFS requires you to develop skill in using the capabilities and knowing the limitations of weather radar. As part of the dual-channel training concept, a review of the knowledge portion of your upgrade training is to be derived from this chapter. You may recall that radar was a subject at Chanute AFB in the weather observer course. The purpose of the radar in that course was to present material necessary for an observer to fulfill his duty requirements; hence, there was little discussion of radar theory, and greater emphasis was placed on classification, recording, and dissemination of radar weather observations. In this section, our emphasis will continue along this line with additional discussions toward further understanding the characteristics and limitations of radar as they affect target detection and scope presentation.

12-1. **Radar Reports.** Meteorology is a relatively new science. The use of radar to identify and observe precipitation areas and associated cloud patterns has significantly advanced this new science. Radar has done for meteorology what the X-ray has done for medicine. Both have allowed internal

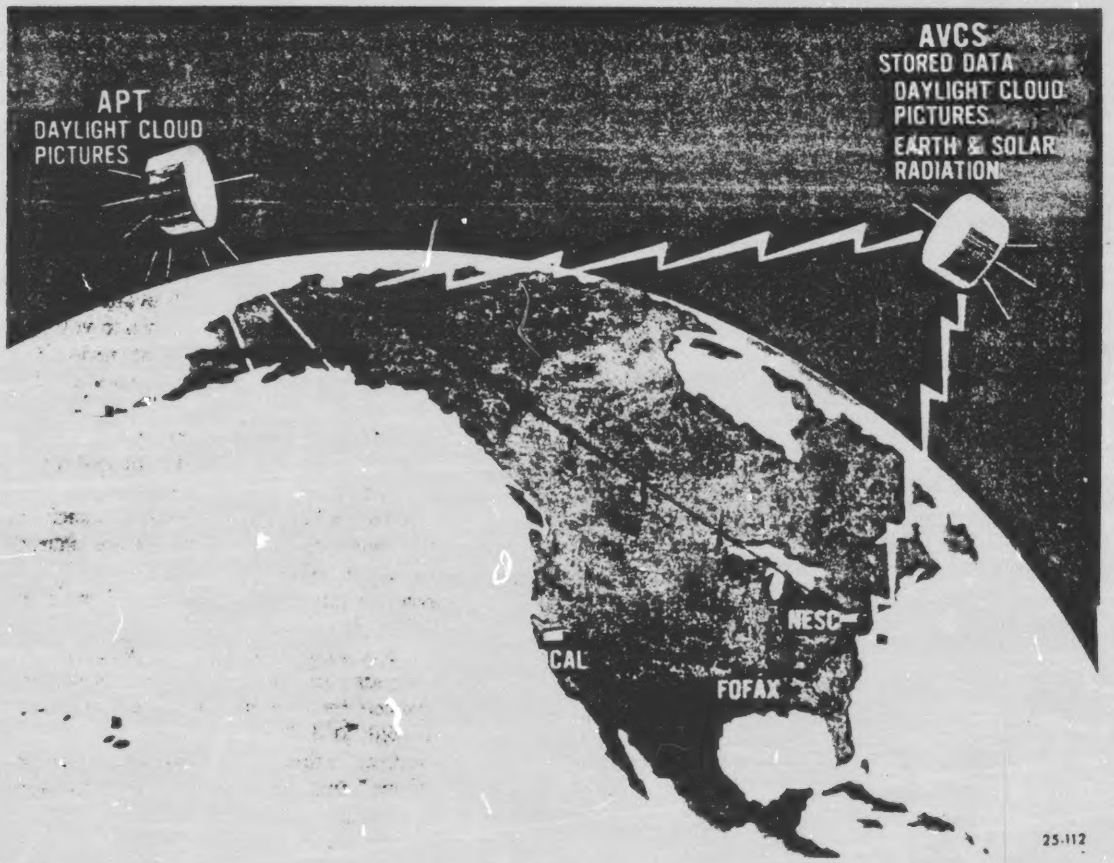


Figure 23. The TIROS operational satellite system.

examination and extensive observation from a point outside the subject of study. Both have proved to be valuable analytic and diagnostic tools. Just as X-ray helps a doctor to understand the nature and extent of a malignancy, so radar enables the weatherman to learn more about the intensity and extent of a storm.

12-2. Gleaning information from the radar set is one thing; passing the information to other interested units is another. Reporting radar weather observations, which includes recording elements of the observation on the radar recording form and encoding the observation for transmission, is the next topic of discussion. Since the transmitted form of the observation follows the form and manner of entry on the radar recording form so closely, recording and encoding are practically done simultaneously.

12-3. In this section we will discuss the elements of a radar observation and the way to transform these elements into RAREP code. To do this, you must know when to take radar observations and how to report them.

12-4. **Reporting Radar Observations.** Each weather detachment with a radar storm detection set, such as the AN/FPS–77, provides weather radar surveillance for its area. Because of the range limitations of weather radar sets, the surveillance area is usually within a 200-mile radius of the station.

12-5. One of the prime purposes of weather radar surveillance is the early detection of hazardous weather phenomena. The list of hazardous weather phenomena includes, but is not limited to, the following:

- Tornadoes.
- Hailstorms.
- Squall lines (rapidly moving or developing).
- Tropical cyclones.

12-6. Generally, you report these phenomena in RAREP code during normal operation. But when they are first detected, give top priority, especially for local agencies, to the immediate dissemination of RAREPs for these phenomena. When the RAREP involves tornadoes or severe thunderstorms, transmit the report as a weather warning (WO) message.

12-7. The way that you report radar observations depends upon whether or not the station is a *primary* network radar station or an *alternate* station, or perhaps is not even designated. Our discussion is based on the assumption that if you know radar reporting procedures for a primary station you should have no difficulty in adjusting to the radar reporting procedures for an alternate station.

12-8. *Hourly radar observation.* Each AWS unit supporting the national radar network is responsible for making a teletype transmission in the hourly radar collective. This means that, even if you observe no significant echoes, you must transmit an operational status report each hour. For example, when an hourly observation shows that no significant echoes are present on the scope, you transmit the contraction "PPINE" each hour until echoes appear on the scope. Other appropriate operational status contractions are listed separately in this section.

12-9. When you observe reportable meteorological echoes on the radar scope, you must report an hourly radar observation as illustrated on the radar recording form (foldout 5). Reportable meteorological echoes are all *precipitation echoes* and all *fine lines* associated with meteorological discontinuities (such as dry cold fronts, prefrontal wind shift lines, and sea-breeze fronts).

12-10. When you report hourly radar observations, begin the observation at a time that enables you to complete it 40 minutes after the hour or earlier. In some cases, you may exceed the standard time because of unavoidable circumstances; however, make every possible effort to complete the hourly observation no later than 40 minutes after the hour. Again, as with airways code, you should observe all the elements of the observation within 15 minutes of the last entry (time of report). Between hourly observation times, special radar observations may be required.

12-11. *Special radar observation.* Special radar observations can be compared to special observations for airways code reports. As with airways code, special RAREPs are encoded whenever significant changes occur. Unlike scheduled hourly observations, special observations include only the echoes of special interest. Be sure to report the selected echoes in complete detail, including remarks to add significant details. Take abbreviated special radar observations and encode them when you *first observe* echoes of the following categories and then every 15 *minutes thereafter as long as they persist:*

a. Echoes of "very strong" intensity.

b. Echoes of "strong" intensity located in or near a severe weather forecast area.

c. Convective echoes with features (such as hooks, holes, and appendages) which are characteristic of severe weather.*

d. Convective echoes whose projected paths intersect.*

e. Convective echoes with severe weather potential, whose tops are within 5,000 feet of the tropopause, exceed the tropopause, or equal or exceed 50,000 feet MSL.*

f. Convective echoes with intensity greater than "moderate" that persist at the same location for an hour or more.*

g. Line echo wave pattern (LEWP).

NOTE: Asterisked (*) items should include descriptive remarks.

12-12. You should also take special radar observations and the indicated action when any of the following situations occur:

a. Encode and transmit information concerning *tornadoes* and *severe thunderstorms,* whether verified or not, that are reported to be occurring or might have recently occurred within radar range.

b. Encode and transmit a complete special radar observation immediately when you receive information, whether verified or not, that an *aircraft* is in *distress* within the maximum range of the radar.

c. Encode, but *do not transmit,* a complete special radar observation immediately when you receive information, whether verified or not, that an *aircraft accident* has occurred during the past 30 minutes within range of the radar.

d. Encode and transmit information concerning the *eye or center of tropical storms* and *hurricanes.*

e. Encode and transmit a special observation immediately when you receive information, whether verified or not, that a *flash flood* is occurring or has recently occurred within radar range of the station.

f. Encode and record a complete special radar observation upon receiving any information, whether verified or not, indicating that an aircraft mishap may have occurred within the maximum effective range of the radar within the past 30 minutes. Identify the observation in remarks as "ACFT MISHAP" and include any other desirable explanatory information. If the information from the observation is locally disseminated, the remark "ACFT MISHAP" should not be included.

12-13. Enter special radar observations on the radar recording form in the same manner as hourly radar observations with one exception—enter the contraction "SPL" in the left margin. Transmit special radar observations with a GMT time group if the special falls at an unscheduled transmission period.

12-14. With the exception of some hazardous weather radar reports and the special report, all reports are encoded in the same basic format. This means that 3-hourly and hourly reports are all encoded in the same format. This is unlike airways code in which each type of observation has a different encoding format. Like airways code, encoding RAREPs requires a basic understanding of the elements that comprise the code.

12-15. **Radar Elements.** Elements of the radar report are indicated on the radar recording form. This form lists the elements in the order (sequence) that you encode them in RAREP code; therefore, the discussion of the elements also reveals the code form. The first element of a radar report, echo character, describes the general shape or form of the echo(es).

12-16. *Echo character.* As we mentioned in Section 8 of Volume 1, echoes are primarily described as cells, lines, or areas. Table 17 lists other echo patterns that may be reported. Most echoes are further classified as to extent of coverage—isolated, widely scattered, scattered, broken, or solid. These descriptive terms refer to the "character" of the echo pattern. Table 17 lists the various classifications of character, defines these classifications, and indicates the contraction to enter on the radar recording form for each classification.

12-17. An echo pattern that is a *line* is a logical arrangement of echoes into a line pattern. The term "line" is not restricted to echo patterns associated with a front or squall line. A line has a length-to-width ratio of at least 5 to 1 and is usually at least 20 miles long.

12-18. You determine echo coverage by deciding how much of the *reported* area is covered by the echoes. The element that follows the echo character is the echo type or kind of precipitation.

12-19. *Echo type.* As indicated earlier, radar echoes are primarily the result of precipitation within the cloud or falling from the cloud. Table 18 shows the standard types of precipitation that you record following the character of the echo.

12-20. Though thunderstorm activity in itself is not a precipitation type, enter a "T," representing thunderstorm activity, whenever the echo presentation indicates conditions characteristic of thunderstorms. For example, enter a radar report of a broken line with thunderstorm activity and rainshowers as "LN TRW." Foldout 5 shows examples of radar observations using the symbols shown in table 18.

12-21. It is not always practical to determine and report every kind of precipitation within an echo system. Rather, your radar observation should reflect the type of precipitation associated with the maximum observed intensity for convective systems. For nonconvective systems, report only the type that is predominant throughout the echo system. However, when you think it is significant, report a secondary precipitation type. On foldout 5 the observations at 0238 and 0337 GMT show examples of two precipitation types for an echo system. When you determine the type of precipitation based on the reflectivity measurements and the vertical structure of echoes, use other sources of information, such as weather maps, surface weather reports, visual observations, and PIREPs.

12-22. *Echo intensity.* The intensity of an echo is determined by the strength of the return signal relative to the range of the target. Both the FPS–77 and CPS–9 weather radar sets have controls which help determine the reflectivity of echoes. Volume 1, Section 8, explains the procedures for obtaining echo intensity with the FPS–77.

TABLE 17
CLASSIFICATION OF ECHOES

CHARACTER OF ECHOES

CHARACTER	DEFINITION	CONTRACTION
Isolated echo	Independent convective echo	CELL
Widely scattered area	An area less than 1/10 covered with echoes	AREA WDLY ⦶
Scattered area	An area 1/10 to 5/10 covered with echoes.	AREA⦶
Broken area	An area 6/10 or more covered with echoes, but with breaks	AREA⦷
Solid area	Contiguous echoes covering usually more than 9/10 of the reported areas.	AREA⊕
Line of widely scattered echoes	(See widely scattered area).	LN WDLY⦶
Line of scattered echoes	(See scattered area)	LN⦶
Line of broken echoes	(See broken area).	LN⦷
Solid line of echoes.	(See solid area).	LN. . ⊕
Spiral band area	Curved lines of echoes, including wall cloud, which occur in connection with a hurricane, tropical storm, or typhoon	SPRL BAND AREA (⦷ or ⦶)
Stratified elevated echo (⊕, ⦷ or⦶)	Precipitation aloft	LYR (⊕, ⦷ or⦶)
Fine line	Narrow, non precipitation echo associated with a meteorological discontinuity	FINE LN

TABLE 18
PRECIPITATION SYMBOLS

PRECIPITATION SYMBOLS

RW	Rain Showers	T	Thunderstorms
R	Rain	ZR	Freezing Rain

INTENSITY FOR PCPN SYMBOLS ABOVE

Very Light	- -	Heavy	+
Light	-	Very Heavy	++
Moderate	No Sign	Unknown	U

PRECIPITATION SYMBOLS, NO INTENSITY SYMBOLS USED.

A - Hail
IP - Ice Pellets
IPW - Ice Pellet Showers
L - Drizzle
S - Snow
SW - Snow Showers
ZL - Freezing Drizzle

TABLE 19
INTENSITY RELATIONSHIPS

Reflectivity (10 Log Z)	Echo Intensity	Intensity Symbol	Theoretical Rainfall Rate (in./hr)
≤13	Very weak	-	<0.01
14-30	Weak	-	0.01-0.1
31-46	Moderate	No entry	0.1-1.0
47-57	Strong	+	1.0-5.0
≥ 58	Very Strong	++	> 5.0

12-23. One important thing to remember when you obtain the echo intensity is to scan the most representative portion of the echo. For example, you must scan the most intense echoes within 100 statute miles *vertically* as well as horizontally to achieve the maximum reading, because many echoes contain the strongest reflectivity at heights near 30,000 feet.

12-24. As indicated earlier, stations have a standard table to convert reflectivity rates to echo intensity. These tables are based on the reflectivity readings as shown in table 19. This table also shows the intensity symbols that you enter with the report and the theoretical rainfall rate for reflectivity values (not entered with the report). You can determine to a useful accuracy, though not precise, the relationship between reflectivity of precipitation echoes and their rainfall rate. The term "echo intensity" and the meteorological term "rainfall rate" are sometimes used interchangeably.

12-25. Like the selection of the precipitation type, the selection of echo intensity is based on the maximum observed intensity for convective systems and the intensity that is predominant in the horizontal extent for other systems.

12-26. Because of special problems involving reflectivity measurement, echo intensities are not reported for *ice pellets, freezing drizzle, drizzle, hail* or *snow;* that is, no intensity entry is required on the radar recording form. When you observe other precipitation types and they are farther than 125 nautical miles from the radar set, you ordinarily do not report echo intensity. In this case, enter the letter "U" after the precipitation type. However, you may assign an echo intensity report to echo areas that overlap this mileage limitation if it is reasonably representative of the entire system. Otherwise, the echo intensity is "U." If you have reason to believe the radar set is performing below standard, report the echo intensity as unknown. Indicate this situation by entering the contraction "ROBEPS" (radar operating below performance standards) in the remarks section. Determining echo intensity is closely related to the next subject—intensity trend.

12-27. *Intensity trend.* The intensity trend is based on the trend of the reflectivity values used to determine echo intensity. For example, if the intensity of the echo complex is *stronger* than previously reported, the intensity trend is said to be *increasing.* The minimum time period to use for determining the intensity trend is 1 hour for *lines* and *areas,* and 15 minutes for *cells.* On the recording form, enter the following intensity trend symbols after the echo intensity:

+	Increasing
–	Decreasing
	No change
NEW	Initial intensity value

12-28. If for any reason you don't know the intensity trend, simply omit the entry. The mileage and equipment limitations for echo intensity also apply to intensity trend. The next element of radar reports is the location of the echo.

12-29. *Direction and distance.* Describe the extent and shape of echoes in terms of direction and distance from the reporting station. Give the direction from the station in whole degrees relative to true north as determined from the azimuth ring on the PPI scope. You report a direction of true north as 360, but you report 015° as 15. Report the distance from the station to the *nearest nautical mile* if severe weather is involved or if special definition is needed. Generally, however, you may use 5-mile increments of distance to make it easier to extract data from the radar scope. You can measure echoes of strong or very strong intensity categories more accurately with respect to direction by using the cursor in the PPI scope. You can also accurately measure the distance of these echoes or other echoes associated with severe weather by the adjustable index or "strobe" on the PPI and A/R scope displays. You can measure distances most accurately on a short operating range. For extensive echoes, however, you must use a longer operating range to determine the distant limits of the echo pattern. The echo patterns reported on foldout 5 beginning with 1736Z through 0337Z, for example, can be evaluated by using the 60-mile range for the nearer echoes and the 200-mile range to detect the extent of the more distant pattern.

12-30. Report irregularly shaped areas of echoes by giving the direction and distance from the station to a series of points along the edge of an echo which, when connected, indicates the general shape and location of the area. Keep the number of points to a minimum, consistent with defining a synoptically significant shape. Report the points consecutively in a clockwise direction. Report cells or circular areas by giving the direction and distance to the center of each cell or area and the diameter (D) of the echo.

12-31. When larger areas of echo are visible at high receiver gain, examine the echoes at reduced gain and at various elevation angles to determine whether or not line activity is present. You must identify and locate *organized lines of activity* separately within the encompassing area of echoes. Whenever possible, use a separate line on the radar recording form for echo parameters that pertain to each related group of echoes, such as lines or areas as shown on foldout 5 for the 0837Z and 0843Z observations. Whether they occur separately or within a reported line or area, report potentially severe weather echoes in as much detail as practicable.

12-32. To report a line of echoes, give the azimuth and distance to the ends of the line or to as many points as necessary on the axis of the line to establish the shape of the line. Record these data in progressive order from the uppermost end of the line to the other end. Of course, for a straight line, just report two points at opposite ends of the line. You usually report the average width (W) of a fairly uniform line, whereas you report marked differences in width in as many widths as necessary to establish the general shape of the line. Report variations in width in the remarks section of the radar reporting form.

12-33. *Width or diameter*. As indicated in the preceding discussion, you report width or diameter for certain types of echoes. If the report is for a line, include the width of the line after the direction and distance data. For example, the entry for a line that is 15 miles wide is "15W." For lines that contain variations in width, enter an explanation in the Remarks section of the observation. The 0938 GMT observation (foldout 5) shows an example of variations in width of a broken line of echoes.

12-34. When the echoes are in a circular area, report only the center point of the area as the direction and distance of the echo. Then report the diameter of the area. For example, the cell at 0738 GMT on foldout 5 shows how to enter the diameter for a circular echo area (cell in this case). The entry "D12" at this observation is the only clue to the size of the echo. For radar reports that are outlined with direction and distance points, do not report diameter. In some cases, however, you can include a remark of the average diameter of each cell or echo within the area in the Remarks section. This is illustrated in the 1736 GMT observation on foldout 5.

12-35. Precipitation at the station may cause a bright, diffuse echo that completely covers the central portion of the scope. In this case, make the distance measurement to the edge of the echo to determine the diameter. Do not report distances and directions from the station; make an entry in the Remarks section to indicate that the echo is centered at the station. This situation is shown as a remark in the 0238 and 0337 GMT observations on foldout 5.

12-36. *Movement*. Determine the speed of movement for the *echo system* on the basis of at least two successive positions 1 hour or more apart. For *cells* and *small elements* you can determine the movement over a 15-minute interval if it is representative. Report the direction of movement in two digits, representing tens of degrees in relationship to true north, using "36" to indicate true north and "0000" to indicate no appreciable movement. Report the movement of cellular echoes individually, whether they are isolated or are contained within an area whose general movement differs from that of the individual cells when their movement is not the same as that of the line. For example, an echo system movement of 260° at 15 knots and cellular movement of 240° at 25 knots is reported as "2615 CELLS 2425."

12-37. Determine movement by plotting successive positions of the centers or boundaries of cells and areas, and by plotting the axes of lines. The direction of movement is the bearing of a line drawn between the successive positions of the centers. In the case of a line, the direction of movement is perpendicular to the axis.

12-38. The displacement, relative to time of the echoes between successive positions represents the speed of movement. The chart in figure 24 is used to find speed of movement by relating displacement (distance) and elapsed time. For example, a displacement of 5 nautical miles in 15 minutes represents a speed of movement of 20 knots.

12-39. The speed of movement of a line is the displacement perpendicular to the axis relative to time. If the line is pivoting or if portions of the line are moving at different speeds, report the movement at enough points along the line to fully describe the movement.

12-40. Figure 25 shows how the various echo patterns recorded on foldout 5 are described in terms of extent and location. Figure 25 shows the observations from 0037 LST (0637Z) to 0237 LST (0837Z). The 0738Z observation on foldout 5 shows an area in which a line of echoes is embedded with an intense cell located at the southern portion of the line. Each is reported as a separate line entry. The 0815Z observation indicates that the precipitation area has moved over the station. The reflectivity of the precipitation at the station prevents detection of the echo line, but you are still able to see the intense cell echo. This reflectivity of the precipitation area over the station

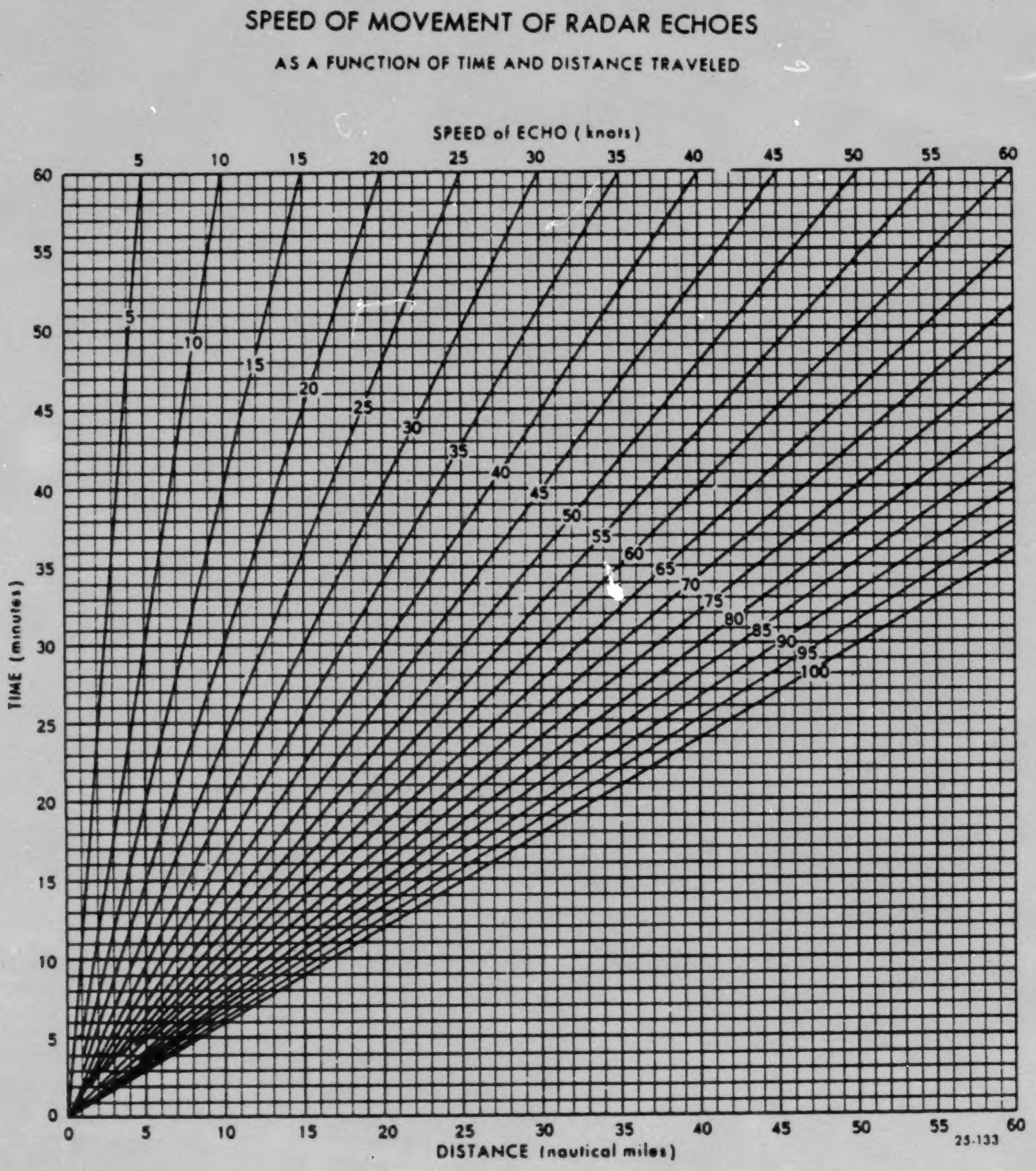


Figure 24. Speed of movement of radar echoes.

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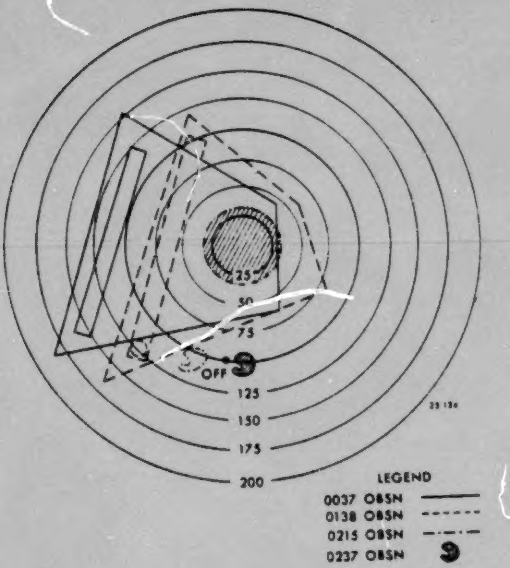

Figure 25. Graphic echo description, 0037 to 0237 LST.

makes it impossible to detect movement of that echo; therefore, none is reported. The movement of the intense cell, however, is reported.

12-41. The remarks included in the 0637Z and 0738Z observations on foldout 5 help to clarify the general movement of the line by indicating different movements at the ends. The remark about hail on the 0738Z observation amplifies the information available about a potentially destructive cell that bears close watching. At 0815Z, development of a hook and a rapid building indicate the potential for producing the most severe weather. The remark on the 0837Z observation, added to the radar observation, substantiates the need to watch this cell and alerts interested agencies to the severe intensity of the storm.

12-42. The next radar observation at 0843Z indicates that the precipitation area has diminished somewhat and a broken line of strong echoes is passing the station. The remarks on foldout 5 indicate different widths along the line and different movements between the line and individual cells. The intense cell on the southern end of the line is in the dissipating stage, as indicated by the apparent anvil formation detected on the RHI scope and a decrease in the echo intensity and diameter. The 0938Z radar observation indicates that the cell has dissipated and that the line is decreasing in intensity. Subsequent observations show a continued decrease in intensity until 1440Z when no significant echoes remain on the scope; hence the operational status contraction "PPINE" is entered.

12-43. *Echo tops.* Though echo height data is useful to both the forecaster and pilot, excessive operation of the radar in the echo height searching mode keeps you from using the radar to evaluate and report the other elements of your observation. For this reason, you should operate the radar so that you get a *judicious sampling* of echo tops without excessive interruption of the normal operation of the radar set. For example, an accurate description of the echo system in terms of location, intensity, movement, and similar qualities is more important than whether the echo tops are 33,000 feet or 36,000 feet.

12-44. When scanning for echo top measurements you must consider several factors. One is range limitations. Range limitations are necessary because of decreasing elevation angles and increasing beam dimensions with distance, in addition to the unknown effect of variation in propagation paths. Another difficulty is the necessity of scanning very high tilt angles that preclude echo top measurement at very close range.

12-45. The designed maximum range of the range height indicator (RHI) of a particular type of radar is also a limiting factor. Therefore, you report echo tops only *within* the following ranges:

- CPS-9—5 to 100 statute miles
- FPS-77—5 to 120 nautical miles
- FPS-41—5 to 100 nautical miles
- WSR-57—5 to 125 nautical miles

12-46. For each observation of an echo system, enter the highest cloud top in the "MAX TOP" column of the radar recording form. For extensive echo systems, such as lines more than 50 miles in length or areas more than 50 miles in diameter, also identify the location of the "MAX TOP" in degrees and nautical miles from the station. Enter the direction and distance in column 9B. In the coded radar report, a maximum top of 44,000 feet MSL located 85 nautical miles from the station on a bearing of 300° appears at MAX TOP 440 AT 300/85. This remark follows the movement of the echo system.

12-47. When an extensive echo system is present, identify the location of additional echo tops that are significant throughout the line or area. Enter these additional echo heights in the Remarks section immediately following the direction and distance of the maximum top. For additional top reports, include the direction and distance from the station for each individual height that you report. Code example:

Max Top	*Remarks*
Column 9B	Column 10
430 26/45	TOP 400AT235/33 TOP 380AT-147/26

Whenever feasible and appropriate, include a remark to indicate that the average tops are below a certain altitude. For example, MOST TOPS BLO 250.

12-48. *Remarks*. The Remarks section of the radar recording form is used to enter data that supports and amplifies the observation as well as additional data that improves the synoptic use of the data. Make the description as brief and informative as possible. Use authorized contractions whenever possible for these entries. Some examples of significant remarks are shown on foldout 5.

12-49. The Remarks section offers the forecaster an opportunity to enter and disseminate data of a more analytic nature than normally falls within an observer's capabilities. Based upon the observer's successive observations, the forecaster might enter a remark such as "COLD FRONT ECHO LINE INDCS TNDCY FOR WV FRMN 345/48 AREA TO N OF THIS PTN OF LINE SHOWING INCRG OVRNG TYPE ECHO."

12-50. During relatively stable conditions it is often possible to determine the approximate height of the 0° C isotherm from the RHI scope by observing the height of the top of the "bright band." The significance of the bright band is its value to the forecaster in determining the height at which aircraft icing may be encountered. The intensity of the bright band gives him an idea of the severity and even the type of icing to be expected. To report the bright band gives him an idea of the severity and even the type of icing to be expected. To report the bright band, enter the contraction "MLTLVL" *and then the height of the top of the bright band* (in hundreds of feet MSL) in the remarks section. For example, MLTLVL 75. As with reporting echo heights, make the corrections for antenna height and earth curvature for your bright band remarks.

12-51. Notice that foldout 5 does not contain entries of bright band data. This is consistent with the meteorological conditions illustrated in the foldout. The instability involved with cumuliform clouds tends to eliminate the conditions which cause the bright band to show up on the RHI scope. On foldout 5 the stratiform clouds that move in during the afternoon, although more stable, degenerate into a precipitation area, as indicated, and become centered over the station. The attenuation of signal caused by this precipitation, and the relatively low surface temperatures prevent the detection of a bright band.

12-52. On foldout 5 the remarks entered with the 1736 and 1938 GMT observations are examples of amplifying remarks added by the forecaster. Remarks on the 1838 and 2037 observations support and amplify the radar report and are appended by the observer from data that he receives from surface observations. This cooperative effort between observer and forecaster in compiling radar observations provides valuable information for the people who use these reports.

12-53. Foldout 5 shows several examples of remarks that support the other elements of the observation. The remarks for the last two observations, 0238 and 0337 GMT, explain why the direction and distance from the station of the echoes are entered (PCPN AREA CNTRD THISTA).

12-54. **Operational Status Reports.** When the radar equipment is operational but no significant echoes are observed, "PPINE" is recorded on the radar recording form where the echo character is ordinarily entered, and is transmitted in the collective. Note that the 1337Z observation of foldout 5 indicates that the line echo has diminished and is decreasing rapidly. At 1440Z, the scope presentation indicates no significant echoes, and "PPINE" is entered.

12-55. An hour later, there are still no significant echoes. The forecaster knows the synoptic situation, and he also knows that the equipment will be needed later in the day with the approach of a front from the southwest. Suppose that the forecaster learns from the weather equipment maintenance man that, in addition to the 1-hour scheduled operational maintenance, there are minor adjustments to make which may require an additional hour of work. In this case, the forecaster instructs the observer to append the contraction "PPIOM" (PPI out of maintenance) as shown in the 1540Z observation. When the contraction "PPIOM" is transmitted, it includes a date-time (GMT) group to indicate when the equipment is expected to resume operation. The date-time group appended to the 1540Z entry on foldout 5 shows an anticipated service outage of 2 hours, and the remark "ALTN SZL" indicates that the alternate station, Whiteman AFB, is assuming the primary reporting responsibility. If possible, always transmit this remark with your last scheduled hourly report before the equipment goes out of service. When you first discover that the radar equipment will be inoperative, immediately notify the alternate station by the most expedient means, because it must assume the primary radar reporting responsibility.

12-56. When you must indicate the operational status of the radar, enter the following contractions on the radar recording form and transmit separately or in combination with other observational data or remarks:

PPINE	Equipment performance normal in PPI mode; no precipitation echoes observed; surveillance continuing.
PPIOM	Equipment inoperative or out of service for preventive maintenance (follow this with a date-time group to indicate the estimated time of return to service).
PPINA	Observation omitted or not available for reasons other than PPINE or PPIOM (follow this entry with a date-time group to indicate the estimated time when observations will be available).

ROBEPS	Radar operating below performance standards.*
ARNO	"A" Scope or A/R indicator inoperative.*
RHINO	Radar cannot be operated in the RHI mode; height data not available.*

NOTE: *Entered in Remarks column.

12-57. **Encoding Radar Observations (RAREPs).** As we pointed out in the beginning of this section, recording and encoding radar observations are almost simultaneous functions. This is because the elements of the RAREP code are arranged to coincide with the order (sequence) of entry on the radar recording form. Use the units and contractions given on the recording form to encode the report for transmission.

12-58. The 0637 GMT observation on foldout 5 is used to illustrate the spacing and separation of the elements in RAREP format:

```
PDQ AREA⦷RW-/+ 42/47 153/65 242/187 320/
    154 2715 MAX TOP 240 AT 170/25 CELLS
    AVG D6
    LN⊖RW/+315/123 243/155 12W 2820 MAX
    TOP 350 AT 275/112 LN
    NWRN END MOVMT 2718 SWRN END
    MOVMT 2823
```

You can see in this coded radar observation that spaces are used between elements that might be confused with other data.

12-59. Unlike the FPS–77, the CPS–9 requires a correction for the curvature of the earth when determining the height of echo tops. Considering these differences, there is one last conversion that you must make for all height determinations—be sure to add the elevation of the antenna above sea level.

12-60. Begin special radar observation reports that occur at nonscheduled transmission periods with the contraction "SPL" and a GMT time group. Example:

```
SPL 1217Z LN⊖ . . .
```

Specials that occur at a scheduled transmission period (hourly) have a date-time group in the weather message heading; therefore, they require only a contraction "SPL" as a prefix to the report.

12-61. When radar observations reveal weather phenomena that are hazardous to aircraft, enter the hazardous radar report in plain language and contractions. Make the observation as brief as possible and encode it in the following format:

(1) Station call letters.
(2) The contraction "RAREP."
(3) Time (GMT) the hazardous phenomenon was observed.
(4) Character of echo(es).
(5) Distance (in nautical miles) and direction (using 16 points of compass) from a known geographical point. It is not necessary to repeat the station call letters.
(6) Direction of movement (using 16 points of the compass).

12-62. Enter radar reports which describe conditions that are hazardous to aircraft operations on the recording form without regard to columnar headings. The call letters and the term "RAREP" are a part of the standard teletype format and are omitted on the recording form. Therefore, simply enter the time and continue your observation through the remaining columns, using as much space as needed. Though local policies generally describe the conditions that are considered hazardous to aircraft, the three reports below show some typical examples of hazardous reports in transmission form:

```
MCF RAREP 0338Z EYE 3211N 7604W D45 1610
FAIR FIX
OFF RAREP 1623Z SVR SQUALL LN 30N THRU
45NE MOVG SE
BLV RAREP 1403Z PSBL TORNADO 20S STL
MOVG ENE
```

12-63. On occasion, you may make an error while encoding RAREP observations. When you discover the error before the report is transmitted, neatly erase the erroneous data and make the corrections. When you discover the error after transmission, draw a red line through the error and enter the correct data above it in red. This is all that is necessary if the error *has been corrected by a later transmission*. However, if the correction is transmitted, enter "COR" and the GMT transmission time in red in the Remarks column.

12-64. RAREPs are transmitted in accordance with AFCSR 105–2, Volume II, *Weather Communications Operations and Management*, which lists weather communications and schedules of transmissions for weather observations. If your station is a primary station, you must meet all scheduled transmissions with a valid observation or an operational status report. In Volume 3 of this course we will discuss the communication responsibilities and procedures that an observer uses in his daily work, and the weather codes that you use daily as well as codes that are used internationally, including plotting and decoding. You will also gain an insight into some of the other duties that an observer performs in everyday station operations.

12-65. At this point refer to your workbook and answer the chapter review exercises for this section.

MODIFICATIONS

Chapter 3 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

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Miscellaneous Publications

International Cloud Atlas, Abridged Atlas, (Volumes I and II), 1956.

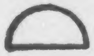
NOTE: None of the items listed in the bibliography above are available through ECI. If you cannot borrow them from local sources, such as your base library or local library, you may request one item at a time on a loan basis from the AU Library, Maxwell AFB, Alabama, ATTN: ECI Bibliographic Assistant. However, the AU Library generally lends only *books* and a limited number of *AFM's*. TO's, classified publications, and other types of publications are *not* available. (For complete procedures and restrictions on borrowing materials from the AU Library, see the latest edition of the *ECI Catalog*.)

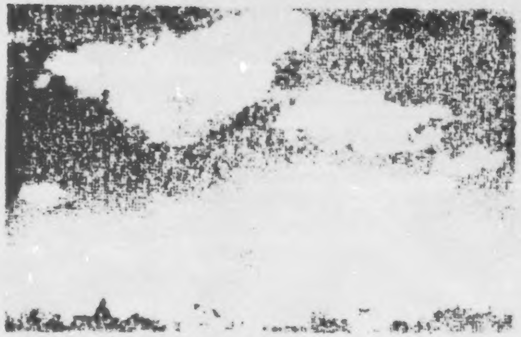
CLOUD CODE CHART

his chart has been prepared with a view of aiding in the interpretation of cloud reports in the International Figure Code

CLOUDS OF GENERA Sc, St, Cu, Cb.

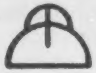
L 1

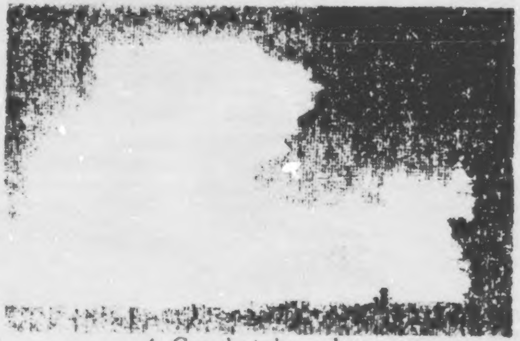




1. Cumulus humilis.

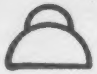
L 3

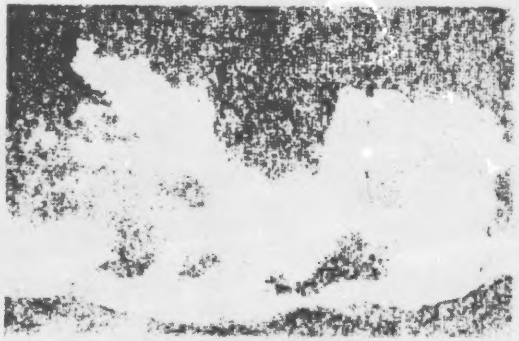




4. Cumulonimbus calvus.

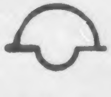
L 2





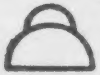
2. Cumulus congestus.

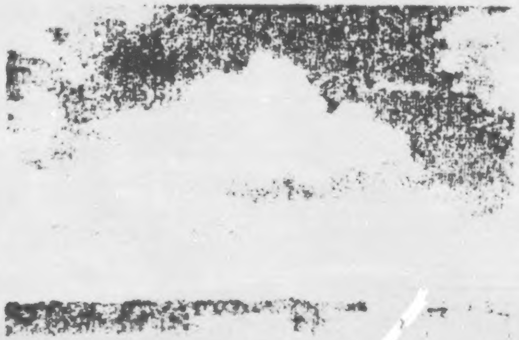
L 4



5. Stratocumulus cumulogenitus.

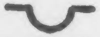
L 2





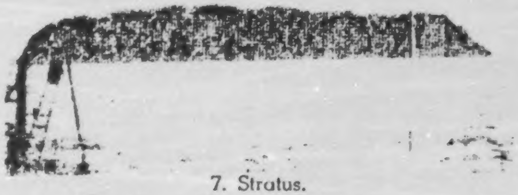
3. Cumulus congestus.

L 5



6. Stratocumulus.

L 6



7. Stratus.

L 7

8. Cumulus fractus of bad weather.

L 8

9. Cumulus humilis and stratocumulus.

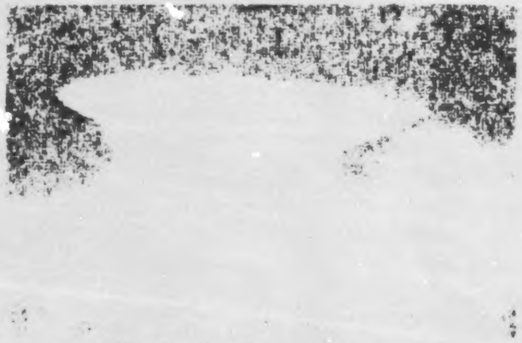
L 8

10. Cumulus congestus and stratocumulus.

L 9

11. Cumulonimbus capillatus.

L 9



12. Cumulonimbus capillatus.

25.85

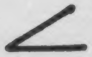
Foldout 1. International Low Cloud Types.

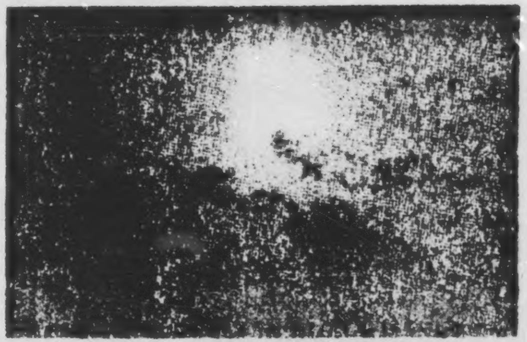
CLOUD CODE CHART

s chart has been prepared with a view of aiding in the interpretation of cloud reports in the International Figure Code

CLOUDS OF GENERA Ac, As, Ns.

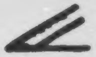
M 1

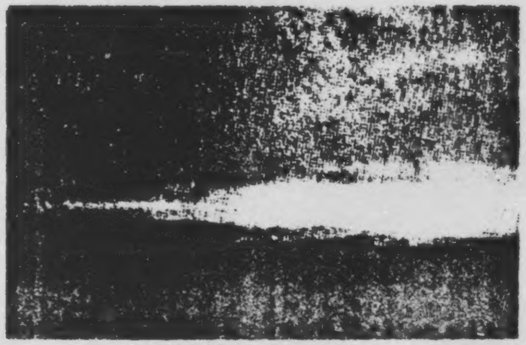




13. Altostratus translucidus.

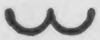
M 2

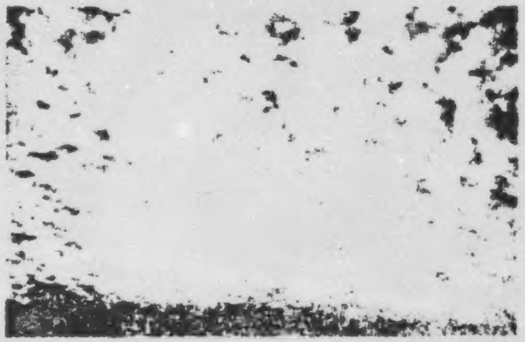




14. Altostratus opacus.

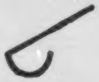
M 3

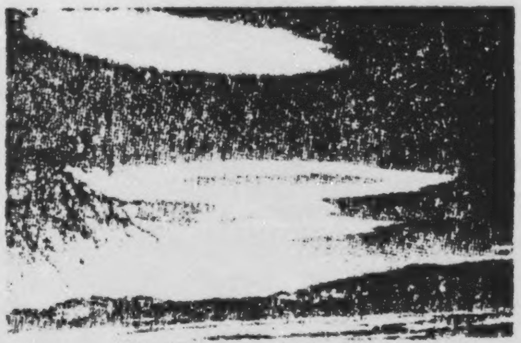




15. Altocumulus translucidus.

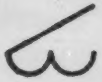
M 4





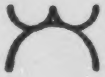
16. Altocumulus lenticularis.

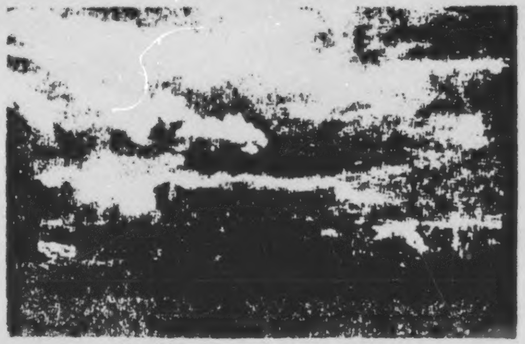
M 5



17. Altocumulus translucidus undulatus.

M 6





18. Altocumulus cumulogenitus.

M 6

19. Altocumulus cumulonimbogenitus.

M 7

20. Altocumulus duplicatus.

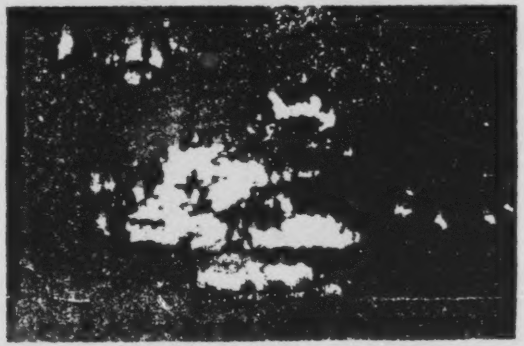
M 7

21. Altocumulus opacus.

M 8

22. Altocumulus floccus.

M 8



23. Altocumulus castellanus.

M 9

24. Altocumulus of a chaotic sky.

25-86

Foldout 2. International Middle Cloud Types.

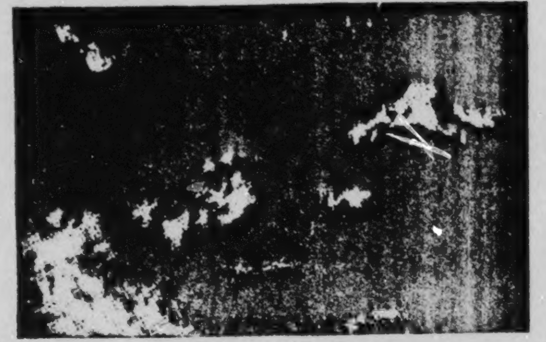
227

CLOUD CODE CHART

…rt has been prepared with a view of aiding in the interpretation of cloud reports in the International Figure Code

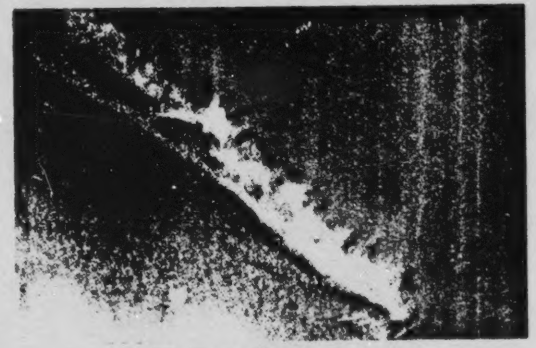
CLOUDS OF GENERA Ci, Cc, Cs.

H 1



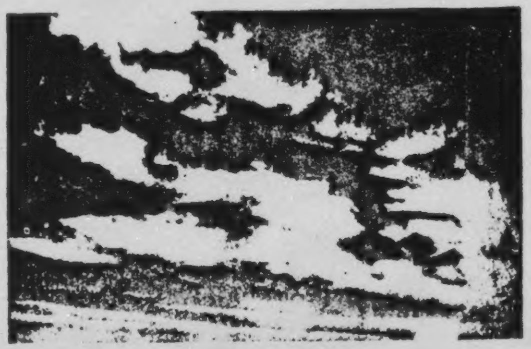
25. Cirrus fibratus

H 1



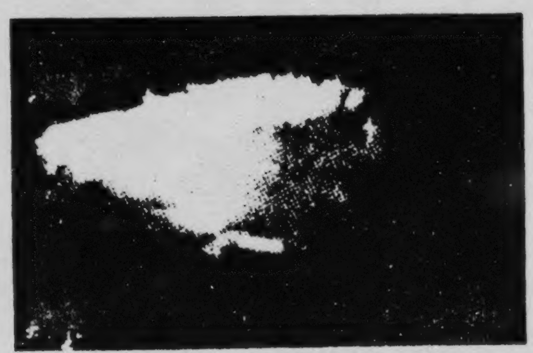
26. Cirrus fibratus floccus.

H 2



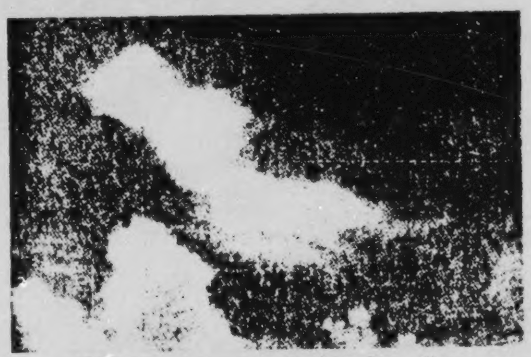
27. Cirrus spissatus.

H 3



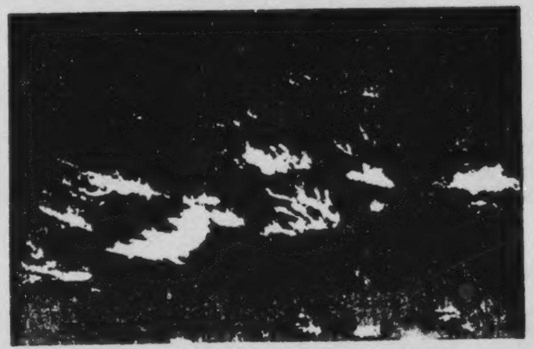
28. Cirrus spissatus cumulonimbogenitus.

H 3



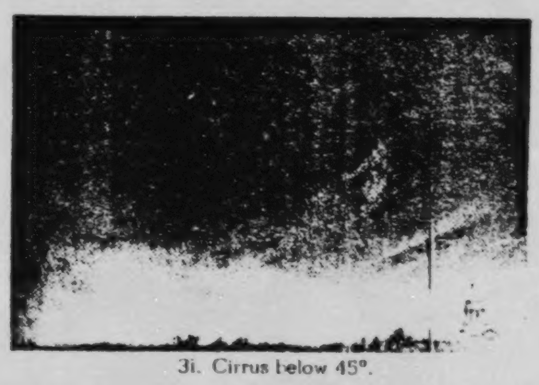
29. Cirrus spissatus cumulonimbogenitus.

H 4



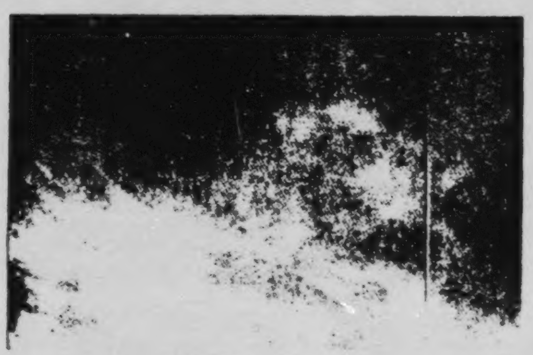
30. Cirrus uncinus.

H 5



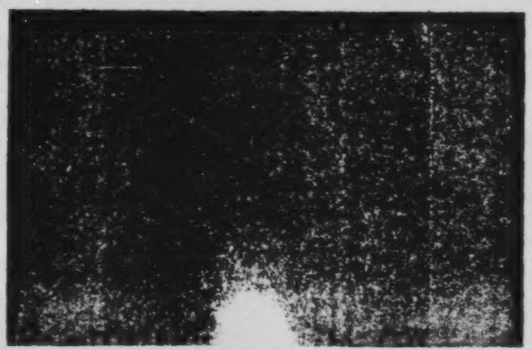
31. Cirrus below 45°.

H 6



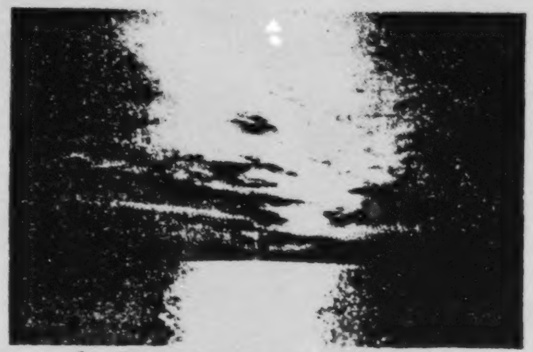
32. Cirrus above 45°.

H 7



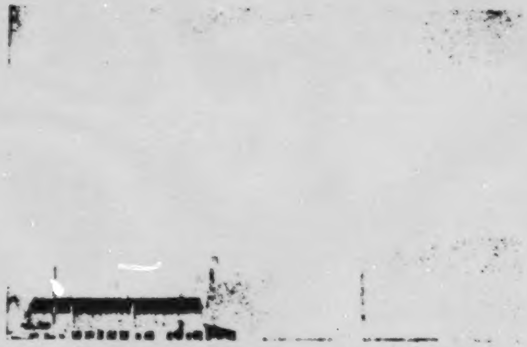
33. Cirrostratus covering the whole sky.

H 8



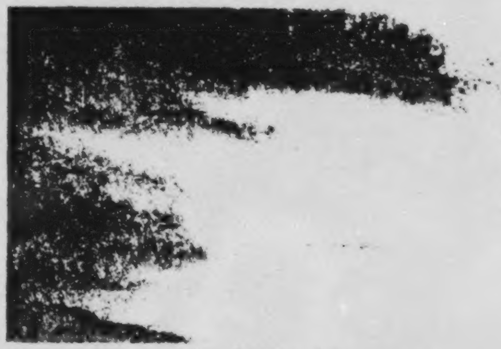
34. Cirrostratus not covering the whole sky.

H 8



35. Cirrostratus not covering the whole sky.

H 9



36. Cirrocumulus.

Foldout 3. International High Cloud ypes.

EDERAL METEOROLOGICAL FORM 1-10 SURFACE WEATHER OBSERVATIONS
(ABRIDGED FORM FOR USE AT AWS STATIONS)

LATITUDE	LONGITUDE	STATION ELEVATION (H_p) Feet (MSL)	TIME CONVERSION (LST to GMT)	MAG TO TRUE	DAY	MONTH	YEAR	STATION AND STATE OR COUNTRY
40° 18' N	88° 09' W	747	+ 6 Hrs	Deg	16	AUG	1974	FAIRWEATHER AFB ILLINOIS

TIME (LST) (2)	SKY CONDITION (3)	VSBY (miles) (4)	WEATHER AND OBSTRUCTIONS TO VISION (5)	SEA LEVEL PRES (mb) (6)	TEMP (°F) (7)	DEW-POINT (°F) (8)	WIND DRCTN (9)	WIND SPEED (knots) (10)	WIND CHARAC-TER (11)	ALSTG (inches) (12)	REMARKS AND SUPPLEMENTARY CODED DATA (All times GMT. DESIRED ORDER OF ENTRY: RVR or RVV, SFC based obsc phenomena, wind shifts, pilot and radar reports of bases and tops, remarks elaborating on preceding coded data, 3- and 6-hourly additive data, radiosonde data, runway conditions, weather modification.) (13)	STATION PRESSURE (inches) (17)	TOTAL SKY COVER (21)	OBS INIT (15)
0032	12⦶ M80⊕	6	F				18	06		984				RW
0037	M80⊕	5	GF		63	[illegible]	16	04		983			10	RW
0112	-X M80⊕	3	GF				16	03		983	F2			RW
0125	-X M90⊕	1½	GF				18	03		984	F4			RW
0150	W6X	¼	F				20	03		983	(IMR18VR24) R18VR28 (F181)			RW
0156	W3X	¼	F		63	61	22	03		983	(IMR18VR24) R18VR28		10	RW
0226	W1X	⅛	F				21	02		982	(IMR18VR20) R18VR24			RW
0235	W0X	0	F				21	02		982	(IMR18VR10-) R18VR10-			RW
0256	W2X	⅛	F	097	61	60	00	00		982	(IMR18VR16) R18VR14/ 705	29.035	10	RW
0324	W5X	1	F				19	04		981	(IMR18VR60+) R18VR50			RW
0358	-X M20⦶ 80⊕	3	F		62	61	16	04		981	F6 (ATC) VSBY NW2 (MET) F DSIPTG RPDLY		10	RW
0419	M20⦶ 80⊕	5	GF				16	07		980				RW
0433	20⦶ M80⦶	7					15	08		980	(ATC) WND 12V18			RW
0455	20⦶	8			63	61	14	08		980	(ATC) WND 11V17 (MET) SC N		3	RW
0555	80⦶	10		086	65	62	15	12		979	612 1010 61	29.000	3	RW
0656	O	10			71	65	17	13	G19	979	(MET) AC NE		0	RW
0752	[illegible]	10			74	68	18	12		978			4	RW
0856	45⦶ E80⦶	10		084	79	70	16	11		978	702 1550	28.995	7	SD
0958	40⦶ E80⦶	10			82	69	19	08		978	(MET) CU S		8	SD
1056	M42⦶ 80⦶	12			84	64	20	07		977	(ATC) CB 20SW MOVG NE (MET) TCU ALQDS		10	SD
1155	M42⦶ 80⊕	15		081	86	58	18	08		977	(ATC) CB SSW-W MOVG NE RWU SW (MET) TCU ALQDS BINOVC /703 1970 61	28.985	10	SD
1231	A43⦶ E[illegible]⊕	15	T				21	10	G19	976	(ATC) TSW-W AND CUHD MOVG NE RWU S-W (MET) TCU N-E			SD
1240	20⦶ R45⊕	8	TRW-				23	16	G33	975	RCD⊕450/(ATC) T ALQDS MOVG E OCNL LTGIC ALQDS 1539 SW2 (MET) PK WND 2333/39			SD
1256	15⦶ 25⦶ R34⊕	2½	TRWA		72	71	22	18	G36	974	RCD⊕450/(ATC) T N-E-S AND CUHD MOVG E FQT LTGICCC N-E-S HLSTO ¼ VSBY E1 (MET)		10	SD
											PK WND 2236/54			
1305											WET RNY			SD
1310	1E⦶ 25⦶ R36⦶ 85⊕	5	TRW-				19	18	G28	974	RCD⊕430/(ATC) T NE-SE MOVG E FQT LTGICCC NE-SW HLSTO ¼ (MET) ⦶V⦶ PK WND 1928/09			SD
1316	20⦶ 35⦶ R85⊕	7	RW-				18	15		973	RCD⊕150/(ATC) T MOVD E CB E MOVG E OCNL LTGIC E			SD
1335	20⦶ 35⦶ R85⦶	10					19	17		973	RCD⦶150/(ATC) CB E MOVG E			SD
1355	20⦶ 40⦶ R85⦶	10			83	63	18	14		972	RCD⦶150/(MET) DRK E WET RNY		8	SD
1456	35⦶ R80⦶	10		067	84	61	19	12		973	RCD⦶150 / 814 1460	28.945	8	SD
1557	20⦶ 35⦶ R80⦶	10			83	59	18	12		974	RCD⦶140/(MET) K10-⦶		8	SD
1656	10-⦶ M35⦶ 85⦶	10			82	60	E19	13		975	(MET) K10-⦶		[illegible]	JN
1755	M32⦶ 85⦶	8		074	80	62	18	14		975	10712 167/ 86	28.965	10	JN
1852	M33⦶ 85⦶	7			79	63	17	11		976	(ATC) VSBY LWR W		10	[illegible]
[illegible]	M25⦶	6	H				17	08		976	(ATC) CIG 25V31			JN
1956	M27⦶ 85⦶	6	HK		77	64	18	06		976	(ATC) CIG 27V30)		10	JN
2052	M25⊕	5	HK	077	76	65	18	05		976	RCD⊕60/(MET) BINOVC W /103 1600	28.975	10	JN
2156	M25⊕	5	HK		76	66	17	06		978	RCD⊕60/(ATC) CIG RGD		10	JN
2257	15⦶ M23⊕	5	HK		75	66	17	05		979	RCD⊕65/90V40		10	JN
2358	15⦶ M23⊕	5	HK	089	74	66	18	04		980	RCD⊕65/90V140/212 1611 86	29.010	10	JN

SYNOPTIC DATA

TIME (LST)	NO.	PRECIP (inches)	SNOW FALL	SNOW DEPTH
	☒			☒
48	(1)	0	0	0
16	(2)	0	0	0
48	(3)	.12	T*	0
49	(4)	0	0	0
	☒			

STATION PRESSURE COMPUTATION

TIME (LST) (39)	0552	1152	1750	2353
ATT THERM (40)	71.5	73.0	72.0	70.5
OBSRVD BAR (41)	29.129	29.118	29.104	29.136
TOTAL CORR (42)	-.130	-.133	-.131	-.128
STA PRES (43)	28.999	28.985	28.973	29.008
BAROGRAPH (44)	28.990	28.985	28.980	29.005
BAR CORR (45)	+.010	0	-.005	+.005

SUMMARY OF THE DAY

PRECIP (68)	SNOW FALL (69)	SNOW DEPTH (inches) (70)
.12	T*	0

PEAK WIND

SPEED (knots) (71)	DRCTN (tens) (72)	TIME (LST) (73)
36	22	1254

ACTIVE RWY AND EQUIP CHANGE

TIME (LST)	RWY NO.	TIME (LST)	RWY NO.
CONT.	18		

REMARKS, NOTES, AND MISCELLANEOUS PHENOMENA (90)

* HAIL
1428 - DRY RWY
1642 - WND EQUIP OUT
1710 - WND EQUIP IN

5 FORM SEP 70 10 PREVIOUS EDITION WILL BE USED.

Foldout 4. Sample . S Form 10.

RADAR WEATHER OBSERVATIONS
(For Use By AWS Units)
WBAN FORM 60

PAGE NUMBER (Start each month with "1" and number in sequence.) 1

TYPE OF RADAR (AN/CPS-9, APQ 13, FPS-77, etc.) AN/FPS-77
STATION KIRTLAND AFB, NEW MEXICO
MONTH APRIL
YEAR 1973
DATE/TIME (LST) 01/0037 TO DATE/TIME (LST) 01/2137

	DATE (GMT) 1	TIME (GMT) 2	DESCRIPTION OF ECHO							MOVEMENT		MAX TOP		REMARKS, WEATHER NOTES, OPERATIONAL STATUS, PHOTOGRAPHIC DATA, ETC. 10	INITIALS 11
			CHARACTER, TYPE, INTENSITY/TREND 3 4	DRCTN/DIST 5A	DRCTN/DIST 5B	DRCTN/DIST 5C	DRCTN/DIST 5D	DRCTN/DIST 5E	WIDTH/DIAMETER 6	SYSTEM 7	CELLS, ELEMENTS 8	HUNDREDS OF FEET MSL 9A	AT (DRCTN/DIST) 9B		
	01	0637	AREA 6 RW-/+	42/47	153/65	242/187	320/154	/		2715		240	170/25	CELLS AVG D6	GEM
	/	/	LN 10 RW/+	315/123	243/155	/	/	/	12W	2820		350	275/112	LN NWRN END MOVMT 2718 SWRN 2823	/
PL	/	0738	AREA 7 RW/+	57/61	120/80	227/165	340/121	/		2721		340	71/32	CELLS AVG D8	GEM
	/	/	LN 10 RW+/+	341/99	223/128	/	/	/	15W	2822	2620	380	275/55	LN NWRN END MOVMT 2620 SWRN 2924	/
	/	/	CELL TRW++/+	227/122	/	/	/	/	D12		2824	(420)	/	HLSTO 1¼ ASSW CELL	/
PL	/	0815	AREA 10 RW/+	/	/	/	/	/	D30				/	PCPN AREA CNTRD THISTA	GEM
	/	/	CELL TRW++/+	202/112	/	/	/	/	D15		2825	480	/	APRNT HOOK SWRN CORNER THIS CELL TOPS INCRD	/
	/	/		/	/	/	/	/					/	420 TO 480 PAST 20 MINS	/
PL	/	0837	AREA 10 RW/NC	/	/	/	/	/	D30				/	PCPN AREA CNTRD THISTA	GEM
	/	/	CELL TRW++/+	180/100	/	/	/	/	D12		2626	490	/	TORNADO RPTD 20E OFF 0830	/
PL	/	0843	LN 6 TRW+/NEW	7/96	176/100	/	/	/		2524	2322	480	10/67	TOP 410 AT 96/10 TOP 400 AT 168/97 LN NRN END 12W	GEM
	/	/		/	/	/	/	/					/	CNTR 27W SRN END 20W	/
	/	/	CELL TRW+/-	168/94	/	/	/	/	D8		2626	450	/	RHI INDCS ANVIL	/
	/	0938	LN 8 TRW+/-	21/104	153/91	/	/	/		2425		460	37/27	LN NRN END 12W CNTR 20W SRN END 15W	GEM
	/	1037	LN 7 TRW/-	31/122	130/99	/	/	/	14W	2525		450	105/83		aEL
	/	1137	LN 6 TRW/-	37/137	119/110	/	/	/	12W	2723		420	90/88		aEL
	/	1233	LN 6 TRW U	43/150	111/129	/	/	/	10W	2920		(420)	/		aEL
	/	1337	LN 4 TRW U	46/168	107/149	/	/	/	6W	2918		(400)	/		aEL
	/	1440		/	/	/	/	/					/	PPINE	aEL
	/	1540		/	/	/	/	/					/	PPIOM 011740Z ALTN SZL	aEL
	/	1736	AREA 6 R-/NEW	293/21	153/62	242/45	/	/				170	/	ELEMENTS AVG D5	aEL
	/	/	AREA 6 R-/NEW	262/147	237/87	209/93	182/200	/				240	220/43	ELEMENTS AVG D8 CLD LYR DVLPG SW QUAD	/
	/	1838	AREA 7 R-/+	350/15	152/71	254/37	/	/		2718	2920	180	230/15	ELEMENTS AVG D5	aEL
	/	/	AREA 8 R-/+	281/132	240/73	205/81	220/150	/		2520		260	230/95	ELEMENTS AVG D8 LGT PCPN RPTD AT SFC 115 SW	/
	/	/		/	/	/	/	/					/	MOST TOPS BLO 220	/
	/	1938	AREA 8 R-/NC	12/21	137/85	243/24	/	/		2715		200	240/15	ELEMENTS AVG D5	JI
	/	2037	AREA 7 R-/-	40/47	135/92	190/28	/	/		2715		200	130/30	ELEMENTS AVG D5	JI
	/	/	AREA 6 R-/-	287/163	249/45	182/59	208/145	/		2522		200	220/70	ELEMENTS AVG D12 LGT SNW RPTD AT SFC 97 6W	/
	/	2138		/	/	/	/	/					/	PPINE	JI
	02	0238	AREA 10 LS	/	/	/	/	/	D25				/	PCPN AREA CNTRD THISTA	JI
	/	0337	AREA 10 LS	/	/	/	/	/	D27				/	PCPN AREA CNTRD THISTA	JI

AWS FORM DEC 60 104 PREVIOUS EDITION WILL BE USED.

23—24 [illegible]

Foldout 5. Sample AWS Form 104.

15-1 231

25251 02 26
WORKBOOK

SURFACE WEATHER OBSERVATIONS
AND STATION OPERATIONS

SELF-TEACHING AIDS
CRE
VRE
SRG

This workbook places the materials you need *where* you need them while you are studying. In it, you will find the Chapter Review Exercises and their answers, and the Volume Review Exercise. You can easily compare textual references with chapter exercise items without flipping pages back and forth in your text. You will not misplace any one of these essential study materials. You will have a single reference pamphlet in the proper sequence for learning.

These devices in your workbook are autoinstructional aids. They take the place of the teacher who would be directing your progress if you were in a classroom. The workbook puts these self-teachers into one booklet. If you will follow the study plan given in "Your Key to Career Development," which is in your course packet, you will be leading yourself by easily learned steps to mastery of your text.

If you have any questions which you cannot answer by referring to "Your Key to Career Development" or your course material, use ECI Form 17, "Student Request for Assistance," identify yourself and your inquiry fully and send it to ECI.

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EXTENSION COURSE INSTITUTE
Air University

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ECI Form No. 17

4. CHANGES FOR THE VOLUME WORKBOOK: VOLUME 2

a. Page 10, Chapter Review Exercise, question 23, line 2: Change "1137 GMT" to "1157 GMT."

b. Page 31, answers for the Chapter Review Exercises, answer 23, line 1: Change "T B37" to "T B 57" and change "WND 21/35 37" to "WND 21/35 57."

c. Page 34, answers for the Chapter Review Exercises, answer 8: Change "30047" to "20047."

d. The following questions are no longer scored and need not be answered: 24, 34, 36, 39, 45, 47, 53, 66, 70 and 79.

STUDY REFERENCE GUIDE

1. *Use this Guide as a Study Aid.* It emphasizes all important study areas of this volume.

2. *Use the Guide as you complete the Volume Review Exercise and for Review after Feedback on the Results.* After each item number on your VRE is a three digit number in parenthesis. That number corresponds to the Guide Number in this Study Reference Guide which shows you where the answer to that VRE item can be found in the text. When answering the items in your VRE, refer to the areas in the text indicated by these Guide Numbers. The VRE results will be sent to you on a postcard which will list the *actual VRE items you missed.* Go to your VRE booklet and locate the Guide Number for each item missed. List these Guide Numbers. Then go back to your textbook and carefully review the areas covered by these Guide Numbers. Review the entire VRE again before you take the closed-book Course Examination.

3. *Use the Guide for Follow-up after you complete the Course Examination.* The CE results will be sent to you on a postcard, which will indicate "Satisfactory" or "Unsatisfactory" completion. The card will list *Guide Numbers* relating to the questions missed. Locate the numbers in the Guide and draw a line under the Guide Number, topic, and reference. Review these areas to insure your mastery of the course.

Guide Numbers 200 through 217

Guide Number	
200	Introduction to Surface Weather Observations; State of the Sky: Cumulus; Cumulonimbus; Stratocumulus; Stratus; pages 1–6
201	State of the Sky: Altostratus; Nimbostratus; Altocumulus; Cirrus; Cirrostratus; Cirrocumulus; Orographic Cloud Forms; Encoding $1C_LC_MC_H$ Group (Column 13); pages 6–13
202	Ceiling and Sky Condition: Layers; pages 13–17
203	Ceiling and Sky Condition: Ceilings; Ceiling/Sky Remarks and Entries; pages 17–21
204	Visibility; pages 21–27
205	Weather and Obstructions to Vision: Storm Phenomena; Precipitation Forms; Character of Precipitation; Intensity of Precipitation; pages 27–31
206	Weather and Obstructions to Vision: Obstructions to Vision; Order of Entry for Weather and Obstructions to Vision; Entries and Remarks for Weather (Column 13); pages 31–37
207	Pressure; pages 37–40
208	Temperature and Dewpoint; pages 40–45
209	Supplementary Data; pages 45–49
210	Miscellaneous AWS Form 10 Instructions; pages 49–51
211	Introduction to Encoding and Disseminating Surface Observations; Types of Observations: Record Observation; Special Observation; pages 52–56
212	Types of Observations: Local Observation; Pilot Reports; AWS Form 12 Entries; pages 56–60
213	Disseminating and Processing Weather Data; pages 60–65
214	Radar Storm Detection Observations; pages 65–75
215	Station Administration and Supply; Administration: Directives; Correspondence and Messages; pages 76–80
216	Administration: Maintaining Records and Files; Air Force Subjective Classification System; Disposition of Records; Orienting Newly Assigned Personnel; The APR Rating Process; Job Performance Counseling; pages 80–85
217	Supply; pages 85–86

CHAPTER REVIEW EXERCISES

The following exercises are study aids. Write your answers in pencil in the space provided after each exercise. Immediately after completing each set of exercises, check your responses against the answers for that set. Do not submit your answers to ECI for grading.

CHAPTER 1

Section 1

Objective: To demonstrate the ability to identify each basic cloud form and its associated phenomena, to encode each cloud form into its appropriate international cloud type for inclusion in airways observations, and to identify and encode the appropriate remarks for certain significant cloud types.

1. Which basic low cloud form is generally white in color, associated with good weather in its early stages of development, and "bulging" in appearance? (1-6, 7)

2. How is the precipitation phenomenon "virga" distinguished? (1-8)

3. When *ragged cumulus* clouds with good weather are present, what low cloud type is encoded? (1-9)

4. What two forms of cumulus, C_L-2, may be reported? (1-10; FO 1)

5. If the sole determination is made on appearance,.how do the tops of a cumulonimbus cloud appear in comparison to a cumulus cloud? (1-12, 13)

6. Why is the dissipating stage of a cumulonimbus cloud often more hazardous than other stages? (1-13)

7. When cumulonimbus clouds are hidden because of overcast conditions or are embedded in other clouds such as nimbostratus, how can you determine their presence? (1-15)

8. How can you distinguish between tuba and mammatus development? (1-16, 17)

9. Both L3 and L9 are cumulonimbus clouds. What is the main difference between these cloud types? (1-18; FO 1)

10. How does a remark for cumulonimbus clouds differ from a remark for towering cumulus clouds? (1-19)

11. Overcast conditions prevent your seeing the entire cloud structure, but you hear thunder overhead. What cloud type do you encode? (1-20)

12. How are stratocumulus clouds in detached elements distinguished from cumulus clouds? (1-21)

13. What is the main difference between L4 and L5 clouds? (1-25; FO 1)

14. What makes an L8 cloud different from all other low clouds? (1-26; FO 1)

15. How is the basic cloud form stratus distinguished from stratocumulus clouds? (1-27)

16. What is the difference between stratus and nimbostratus clouds regarding precipitation and thickness? (1-29)

17. What is the difference between L6 and L7 stratus cloud types? (1-31, 32; FO 1)

18. How can you use the appearance of the sun to identify the cloud form altostratus? (1-35)

19. What is the height range for middle clouds in the middle latitudes? (1-37)

20. How do M2 clouds differ from M1 clouds? (1-38–40; FO 2)

21. Nimbostratus can be distinguished from opaque altostratus by a ____________________________ appearance. (1-43)

22. When altocumulus clouds are in the form of individual elements, how are they differentiated from stratocumulus clouds which are also in individual elements? (1-44)

23. How can the presence of a corona aid you in identifying the correct cloud form? (1-48)

24. What is the primary difference between M3 and M4 clouds? (1-49, 50; FO 2)

25. What middle cloud is a semitransparent altocumulus cloud that progressively invades the sky and thickens as a whole? (1-51; FO 2)

26. Which middle cloud type is formed exclusively from the spreading out of cumulus or cumulonimbus clouds? (1-52; FO 2)

27. What are the main features of M7 clouds? (1-53; FO 2)

28. List the two different appearances that altocumulus, M8, may assume. (1-54; Fig. 5; FO 2)

29. What middle clouds appear heavy and stagnant and at several levels? (1-55; FO 2)

30. A cloud that appears to be in patches and filaments describes what basic cloud form? (1-56)

31. What is the height range for high clouds in the middle latitudes? (1-56)

32. What is the criterion that separates coding between H1 and H4 clouds? (1-59, 62)

33. By definition, H2 and H3 clouds are very similar. What is the key to making the correct selection? (1-60, 61)

34. What is the primary difference between cirrus and cirrostratus clouds? (1-63)

35. How can the sun aid you in detecting the presence of a cirrostratus cloud? (1-64)

36. What is the only difference between H5 and H6 clouds? (1-66, 67; FO 3)

37. When you classify a cloud as H7, what is the main restriction that you must consider? (1-68; FO 3)

38. What is one case where H8 clouds can increase in amount and still be classified H8? (1-69)

39. How can you distinguish between high altocumulus and cirrocumulus clouds? (1-70)

40. When cirrocumulus clouds are present, what must you consider before you encode the cloud as H9? (1-73)

41. Why are orographically formed clouds, such as lenticular and rotor clouds, significant to the pilot? (1-74)

42. For what two orographically formed clouds should you add a remark in your observation? (1-78)

43. The foehnwall cloud is usually classified as what type cloud? (1-79)

44. The following cloud types are present: L2, L4, L9, M6, H3, and H4. How is this situation encoded in a cloud code group? (1-81; Table 1)

45. A layer of nimbostratus is present at 3,000 feet, and an overcast of altocumulus is present above. What is the cloud code group? (1-84; Table 1)

Section 2

Objectives: To be able to record the correct sky cover symbols, reportable height values, and ceiling designators that combine to make a column 3 entry for sky condition; to recognize the criteria for entering significant remarks in column 13 (Form 10) that pertain to sky condition entries.

1. When you are considering whether or not clouds or obscuring phenomena aloft are a layer, what is the essential requirement? (2-3)

2. What does a sky cover symbol indicate? (2-4)

3. The total sky cover at and below a given level is 8/10 coverage of which 4/10 is transparent. How is this indicated on Form 10? (2-12)

4. For layer heights of 4,350 and 11,600 feet, what is entered in column 3? (2-15; Table 4)

5. What is a ceiling? (2-18)

6. Which ceiling designator is used in column 3 if you obtain a measurement from the RBC of 4,500 feet for a ceiling layer and an aircraft measurement of 4,000 feet for the same layer? (2-19)

7. In addition to measurements by ceilometer and ceiling lights, how else can the ceiling designator "M" be obtained? (2-20)

8. What is the correct column 3 entry for 4/10 stratus (3/10 thin) at a measured height of 1,800 feet to the south through north, 0/10 cumulus at an estimated height of 3,500 feet overhead, and 3/10 altocumulus east at a cloud detection radar height of 9,300 feet? (2-4, 8, 12, 21; Table 4)

9. What is the correct column 3 entry for 2/10 fog, 2/10 cumulus fractus at an estimated 3,500 feet, and an overcast of semitransparent altocumulus measured by an aircraft at 13,500 feet? (2-4, 7, 11, 18, 22; Table 4)

10. When you use a balloon to obtain a ceiling height (B), what point in the balloon's flight is used for the ceiling height? (2-23)

11. When you obtain a ceiling height by using a ceiling balloon during moderate rain, what ceiling designator must you use? (2-25)

12. When can you use the convective cloud height diagram to obtain estimates of convectively formed clouds? (2-28)

13. How does an indefinite ceiling differ from other ceilings? (2-30)

14. What sky condition data should you enter in column 3 for a completely obscured sky if an aircraft reported 10 minutes ago that the downward vertical visibility was 400 feet? (2-30)

15. What sky condition data is entered in columns 3 and 13 when a measured broken ceiling is fluctuating rapidly between 2,200 and 2,900 feet and no other clouds are present? (2-33)

16. The present sky condition of 25⌽E65⦷ is representative of the actual situation; however, the broken layer is occasionally scattered. How can you indicate this on Form 10? (2-35)

17. At 1851Z, 5 minutes ago, a pilot reported the tops of the overcast that you are reporting in column 3 to be at 4,600 feet MSL. At 1831Z, 25 minutes ago, another pilot had reported a broken layer at 16,500 feet MSL with tops at 20,000 feet 15 miles from the station. What is the correct Form 10 entry and in which column is it entered? (2-36)

18. Which remark, if any, is required when there are breaks in a portion of a broken layer at 800 feet and west of the station? (2-40, 41)

19. Column 3 has a "-X" sky cover symbol reported. How is this partly obscured condition and the phenomenon involved explained? (2-45)

20. If you report a layer of smoke in column 3 as "40⌽, "what remark, if any, is entered in column 13? (2-46)

Section 3

Objectives: To be able to make proper entries for prevailing visibility as well as accompanying remarks for sector and variable visibility; also, to understand the coding of runway visibilities.

1. What kind of object makes the best day marker? (3-4)

2. Give two causes for apparent reduction in visibility. (3-5)

3. The most distant marker is at 6 miles, but you judge the visibility to be at least 10. Can the visibility be reported as 10+? Why? (3-7)

4. If you observe a prevailing visibility of 2¾ miles, what is the reportable value? (3-7; Table 5)

5. In what two ways can sector visibility be used to report the visibility around your station? (3-8–10)

6. What light setting is used to determine runway visibility? (3-13)

7. Both the 1- and 10-minute values are observed for RVR. What is the proper HIRL setting for each value? (3-15)

8. If the prevailing visibility is 7/8 mile and the RVR 6,000+, must RVR data be reported? Why? (3-16)

9. Assume that you observe values of 2¾, 3½, and 3 miles during observation. Why is the prevailing visibility not reported as variable? (3-19)

10. The visibility in the following 90° sectors are: NE2NW13/4SE3SW21/2. What is the column 13 sector visibility remark? (3-22, 23)

11. Make a complete RVR entry from the following data: (1) highest HIRL is in use; (2) 1-minute rollout visibility is 1,200, touchdown visibility is 1,400; (3) 10-minute visibility 1,000; and (4) runway 18 is in use. (3-25, 26)

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Section 4

Objectives: To demonstrate a knowledge of the meteorological definitions for weather and obstructions to vision that are entered in column 5; to be able to enter the correct significant remarks for weather and obstructions to vision in column 13.

1. How is a hurricane reported on AWS Form 10? Why? (4-5)

2. What weather phenomenon is present when a funnel-shaped appendage on a cloud reaches the ground? (4-6)

3. What intensity of thunderstorm is present if the maximum wind speed is less than 40 knots and 1-inch hail is observed? Why? (4-9)

4. How is drizzle distinguished from rain? (4-12)

5. Under what circumstances is precipitation classified as "freezing"? (4-13)

6. What type of entry should be reported in the observation if solid precipitation is in the form of snow grains which are encased in a thin layer of ice with a diameter of 0.2 inch or less? (4-15)

7. How is hail distinguished from other solid precipitation? (4-16)

8. What form of solid precipitation falls almost exclusively from convective clouds, may rebound or burst when it strikes hard surfaces, and is crisp and easily compressible? (4-18)

9. How do snow grains differ from snow? (4-17, 19)

10. What is the only difference between continuous and intermittent precipitation? (4-22, 23)

11. What type of precipitation changes intensity rapidly or begins and ends abruptly? (4-24)

12. Which solid precipitation forms do not require intensity symbols? (4-26)

13. What is the best method to determine the intensity of snow or drizzle when they are not occurring simultaneously? (4-27, 28; Table 10)

14. Assume that the present visibility is 8 miles and haze is present in all sectors. What entry should you make in column 5? Why? (4-29)

15. What is the main difference between fog and ground fog? (4-31, 32)

16. What is the main difference between blowing snow and drifting snow? (4-33)

17. In what way is ice fog similar to ice crystals? (4-20, 34)

18. What are the five lithometeors that are reported as obstructions to vison on Form 10? (4-36)

19. If the sun's disk is pale and colorless, what obstruction to vision is probably present? (4-37)

20. Smoke at a distance may appear greyish or bluish in color. How does the sun appear when viewed through smoke at sunset or sunrise? (4-41)

21. Using the appropriate symbols, group the following weather and obstructions to vision into the correct order of entry for column 5 of Form 10: fog, light rain showers, severe thunderstorm, hail, moderate freezing drizzle, moderate drizzle, and a funnel cloud. (4-42, 43; Tables 11, 12)

22. What column 13 remark should you make when the state police sight a tornado moving east at 1610Z, 15 miles west of OKC? (4-46, 49)

23. Thunder has just been heard in the southwest through the east and overhead. All storms are moving eastward, and thunder was first heard at 1137 GMT. The wind gusts are 210 at 35 KTS. What is the correct column 13 remark for this situation? (4-50)

24. How should you enter column 13 remarks for this situation? A thunderstorm begins at 1131Z, ends at 1147Z, and has peak gusts of 45 knots at 1141Z from 270°. The storm has apparently moved east, where you can still see occasional lightning cloud to ground and cloud to cloud. The beginning time of this storm has not been transmitted. (4-50–55)

25. Hail is occuring during a thunderstorm. The hail began at 1235Z, and the largest hailstone measured 1¼ inches. How should you enter this remark in column 13? (4-56, 57)

26. How does the remark "INTMT R–" differ from the remark "R–OCNLY R"? (4-59)

27. In what circumstance can you report shallow ground fog? (4-59)

Sections 5, 6, and 7

Objectives: To be able to make the proper entries for sea-level pressure, station pressure and altimeter setting, temperature, dewpoint, and wind speed, wind direction and character; to determine when significant remarks for pressure and wind are appropriate.

1. What is the definition of atmospheric pressure? (5-5)

2. What are the three instruments that measure atmospheric pressure? (5-7)

3. What does the term "station pressure" mean? (5-8)

4. If the aneroid barometer is replaced or relocated, what must be done? (5-10)

5. What additional tasks must you perform when there is no aneroid barometer to use for pressure readings? (5-11)

6. What three elements are needed to calculate sea-level pressure? (5-12)

7. How does the pilot use the altimeter setting value? (5-18, 19)

8. What AWS Form 10 pressure entries can be obtained using the pressure reduction computer? (5-17, 20)

9. What should you enter in column 12 for an altimeter setting of 28.89? Explain your answer. (5-21)

10. When the aneroid barometer is in use, only three columns on AWS Form 10 need to be completed. How many columns or lines are completed when the microbarograph is in use? (5-22)

11. During your observation, when (in what sequence) should pressure determinations be made? (5-23)

12. What entries are made in column 17 of AWS Form 10 and at what times? (5-23)

13. What entry is required if the microbarograph is reset to "zero" correction? (5-26)

14. What is the basic difference between the significant pressure remarks "PRESFR" and "LOWEST PRES"? (5-28)

15. What are the two methods used by the Air Force to obtain the free air temperature? (6-1)

16. What is another name for free air temperature? (6-2)

17. What is the name of the temperature beyond which further cooling produces visible condensation? (6-4)

18. The AN/TMQ–11 hygrothermometer provides direct reading of both ________________________ and free ________________________ on separate scales. (6-5)

19. Using the following values, solve for the dewpoint (DP) by using interpolation. (6-6)

Air Temperature	*Wet-Bulb Depression*
	7.0
72	61
72.7	DP
73	62

20. When is the "Ti" scale on the psychrometric calculator used to find dewpoint? (6-7, *a*)

21. How would an observed temperature and dewpoint of 23.3° F and 08.5° F, respectively, be entered on AWS Form 10? (6-8)

22. To which "north" is the wind direction equipment oriented? (7-2)

23. When reading direction from the RO–2 recorder, which scale gives true direction? (7-3)

24. What is the agonic line? (7-4)

25. What is one method used by AWS to estimate wind direction and speed? (7-5,6)

26. How can you identify gusts on AWS Form 10? (7-8)

27. How can you identify a squall on AWS Form 10? (7-9)

28. Give the criterion for reporting a wind shift. (7-10)

29. Encode a wind from 190° at 18 knots gusting to 24 knots. (7-11)

7. When snow has drifted, how can you obtain a reasonably accurate snow depth measurement? (8-16)

8. What is the code for a 24-hour precipitation amount of 0.47 inch of liquid precipitation? (8-17–19)

9. In column 13, what does an added group of "RADAT 84M019045051/1" indicate? (8-27)

10. What does the column 13 entry "RAICG 95 MSL" indicate? (8-29)

11. What does the column 13 entry "LSR 15 SANDED" indicate? (8-32–34)

12. What four conditions require that weather modification remarks be recorded in column 13 of AWS Form 10? (8-35)

13. If you are assigned to a weather unit within the CONUS or Alaska, when are you normally required to transmit radiation intensity data? (8-37)

14. What statistical column on AWS Form 10 requires an entry every record observation? (9-3)

15. How are the time entries in column 42 used to divide the observing day? (9-4)

16. In what summary column is the total 24-hour precipitation from "mid to mid" entered? (9-8)

17. What three types of data are summarized for each 24-hour period? (9-8, 9)

18. When is the active runway recorded in column 90 on AWS Form 10? (9-12)

19. If the column 7 temperature is missing, what is the proper column entry? (9-15)

20. What is meant by *filing* time? (9-16)

21. You discover an altimeter setting error after your observation is disseminated. What should you do to correct the error and transmit the correction? (9-17)

CHAPTER 2

Section 10

Objectives: To be able to take local, special, and record observations; to encode surface weather observations into airways code directly from Form 10 entries; to arrange pilot report information into understandable format, using accepted contractions, symbols, and plain language; and to encode these reports into PIREP code format.

1. Airways code is derived from the order (sequence) of entries of the individual elements on ______________________________ . (10-3)

2. Within what time period should you observe all the elements of an observation? (10-4)

3. State what type of airways observation the following report represents:
RAN 300 10 57/51/2610/991. (10-5, 6)

4. What is the main difference between hourly and 3-hourly airways observations? (10-12, 13)

5. What is wrong with the following 6-hourly airways report?
RAN 30⌽10 021/71/60/2613/997/ 72111 1200 72/TCU W–N. (10-14, 15)

6. If there is a break in the hourly observation schedule, what must you do within 15 minutes after returning to duty? (10-20)

7. The last *recorded* observation indicates the sky condition as "15⦶M30⊕." If your *latest* evaluation shows that the sky condition is "8⦶15⦶M30⊕," what type of observation, if any, must you take? (10-20)

8. The last *recorded* observation indicates the sky condition as "M30⊕5RW." If your *latest* evaluation shows the condition to be "M30⊕21/2RW," what type of observation, if any, must you take? (10-21)

9. When the 10-minute RVR decreases to less than nationally published minima for the runway in use, what type of observation, if any, must you take? (10-22)

10. A funnel cloud has been reported by the public to have occurred 4 hours ago near your station. What should you do? (10-23)

11. Your recorded observation indicates that snow is occurring and suddenly ice pellets begin. What type of observation, if any, must be taken? (10-24)

12. Special observations are taken when it has been determined that a "WSHFT" has occurred at your station. In what other instances are specials taken for wind changes? (10-24)

Use the following series of partially complete observations to answer exercises 13 through 17.

Time List	*Observation*
1256	20⦶40–⦷7
1307	20⦶M40⦷5GF
1315	16⦶M38⊕3GF
1328	-X16⦶M35⊕21/2F
1341	-X11⦶M30⊕2F
1346	-X7⦶M30⊕11/2F
1355	-X7-⦷M29V⊕11/4L–F

13. Why was the observation at 1307 taken? (10-20–24, 27–29)

14. What is the first observation that should be classified as a special and for what reason? (10-20–24, 27–29)

15. Why was the observation at 1341 taken? (10-20–24, 27–29)

16. The observation at 1346 was taken because of mandatory special criteria. Identify the criteria. (10-20–24, 27–29)

17. What mandatory special criteria can be identified in the last observation (1355), which coincides with the hourly observation time? (10-20–24, 27–29)

18. When you are notified of an aircraft mishap, what action must you take? (10-28, *a*)

19. At stations required to report the 1-minute RVR, what type of observation, if any, is taken when criteria are first met? (10-28, *c*, (1))

20. When are local observations for altimeter settings recorded on AWS Form 40? (10-29, *c*)

21. What are the first coded elements of any pilot report? (10-33, 34)

22. How should you encode the location (or extent of a phenomenon) in a PIREP if the pilot reports that he observed the phenomenon from Milwaukee (MKE) to 30 miles west of Toledo (TOL)? (10-34, 35)

23. When encoding the observation time for PIREPs, for what must you be alert? (10-36)

24. What does the following data, extracted from a PIREP, indicate? DEN–LIT 1615–1902 (10-33–38)

25. What method is used to encode PIREP cloud heights (altitudes)? (10-39, *a*)

26. What are several types of PIREPS that are considered hazardous weather? (10-40)

27. What are the four standard contractions for turbulence intensities used with PIREPs? (10-45)

28. What does the PIREP phenomenon "SVR CAT 260 C–5A" indicate? (10-44–47)

29. Encode into PIREP format: light icing, both clear and rime, at 4,500 feet, reported by the pilot of a T–29 aircraft. (10-49, 50)

30. When the aircraft type is unknown, why should you add the remark "ACFT UNK" to PIREPs that contain reports of turbulence of icing? (10-47–49, 51)

31. Encode in PIREP format the following received from the pilot of an F–111: A broken layer at 6,000 feet; a layer with bases at 30,000 feet, tops at 33,500 feet, and amount unknown; and contrails at 41,000 feet. (10-52)

32. When is the term "electrical discharge" reported by a pilot? (10-55)

33. At 1127Z, the pilot of an F–110, flying 10 miles southwest of Chanute AFB, Illinois (RAN), reports a wind of 45 knots from 279° at 8,000 feet, light clear air turbulence between 11,000 feet and 13,000 feet, and an overcast with bases at 31,000 feet. As the duty observer at Chanute AFB, how should you encode this for transmission? (10-37–39, 44–47, 49, 52, 57)

34. When you are disseminating encoded PIREPs taken from AWS Form 12, which types of phenomena require longline dissemination as a warning (WO)? (10-59)

Section 11

Objective: To be able to explain why the reporting sequence of the weather elements and procedures for tape preparation are necessary for efficient local and longline transmission; to explain the techniques used to disseminate weather data by voice and autographic systems; and to explain the steps in processing and displaying teletype, facsimile, radar, and satellite charts.

1. Name three receiving units that are normally on the local dissemination list for surface observations. (11-2)

2. The standard format for local dissemination is based upon the requirements of ____________ and usually follows across __________________________ from column 1 through 13. (11-4)

3. What contraction is never locally disseminated over the transcriber? (11-4)

4. When using the intercom system, how should you speak? (11-5)

5. When you are establishing your first contact on an intercom, what should you be sure to do? (11-5)

6. How would a fraction visibility of 1½ be sent via intercom system? (11-5, *b*)

7. When disseminating the altimeter setting, how many digits are used? (11-5, *f*)

8. How would a fractional sector visibility of S 1½ be sent via intercom system? (11-5, *g*)

9. What is your next priority after local dissemination? (11-7)

10. The ADCAD/OWS teletype system basically consists of how many circuits? (11-8)

11. What is meant by the term "H–Time messages"? (11-10)

12. With your observation tape properly prepared and inserted in the transmiiter, must you transmit the message manually? Explain your answer. (11-10)

13. What is meant by the term "T-Time messages"? (11-12)

14. What is meant by the term "special category traffic"? (11-14)

15. What are the two types of SP traffic presently polled on the OWS network? (11-15)

16. TYPNO (OK) messages are transmitted on what circuit? (11-18)

17. The mainland U.S. is divided into how many weather circuits? (11-21)

18. What AWSM contains the listing of U.S. weather communications bulletins? (11-21)

19. Who determines the system used for observers to process weather facsimile charts? (11-22)

20. If you are required to outline a severe weather area on a radar chart, what color should you use? (11-23)

21. If your weather station is receiving weather charts on a FOFAX network, what is one type of chart you are receiving? (11-26)

22. Processing of satellite charts is normally the ______________________ function. (11-27)

Section 12

Objectives: To be able to describe the elements of the radar report and explain the procedures for encoding each element and entry of operational status reports for transmission.

1. What is one of the prime purposes of weather radar surveillance? (12-5)

2. If your station is a primary reporting station for radar observations, what is reported when no echoes are observed on radar, and how often must you transmit this report? (12-8)

3. When should you report hourly radar observations? (12-9)

4. You have been encoding hourly radar observations. Shortly after an hourly report you are informed that an aircraft may have crashed during the past 30 minutes within range of the radar. What must you do? (12-12)

5. What does "LN0" indicate in a RAREP report? (12-16–18; Table 17)

6. If you have difficulty in determining the type of precipitation associated with radar echoes, how can you obtain this information? (12-21)

7. Why is it important to determine the reflectivity of radar echoes? (12-22–24)

8. When do you omit radar echo intensities? (12-26)

9. When should you report radar echo intensity as unknown ("U")? (12-26)

10. How can you obtain the intensity trend for radar echoes? (12-27, 28)

11. How are the direction and distance of radar echoes reported? (12-29)

12. How should you identify the location of irregularly shaped radar echoes? (12-30)

13. How do you report the location of cells or circular areas of radar echoes? (12-30)

14. How do you report the size and shape of radar echoes in the form of a line? (12-32)

15. What does the entry "12W" indicate when it is encoded with a radar observation? (12-33; FO 5)

16. How do you indicate the size of echoes that are in a circular area or a cell? (12-34; FO 5)

17. How is the movement of radar echoes obtained and reported? (12-26–39)

18. How should you report the movement of an echo that is centered over the station and is causing widespread precipitation that prevents you from detecting the shape (line, etc.) of the echo? (12-40)

19. For radar reports, what limitations must be considered for all values of cloud tops? (12-44)

20. What is the purpose of the Remarks section of the radar recording form? (12-48)

21. How is the bright band reported with radar observations? (12-50, 51)

22. Which operational status contraction should you include with a radar observation if RHI scope data is unavailable? (12-56)

23. How is encoding special radar observations different from encoding hourly reports? (12-60)

24. Suppose that your station (ABQ) is in the mountain standard time zone. At 1215 LST, you observe radar echoes on the FPS–77 that appear to be funnel clouds. The echoes are moving on a heading of 070° and are located 30 miles west. How should you encode the RAREP? (12-61, 62)

25. How do you correct an error on a RAREP that has already been transmitted? (12-63)

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MODIFICATIONS

Pages 24 -26 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

ANSWERS FOR CHAPTER REVIEW EXERCISES

CHAPTER 1

Section 1

1. Cumulus.

2. Virga can be distinguished by the dark area beneath the cloud that completely disappears (evaporates) before it reaches the ground.

3. A ragged cumulus cloud assoicated with good weather conditions is encoded as low cloud "1."

4. Cumulus, C_L-2, may be reported as moderately developed or towering.

5. Cumulonimbus clouds usually have greater vertical and horizontal extent (massive) and their tops must have at least some stratification or must lack clear outlines.

6. The dissipating stage of a cumulonimbus cloud usually releases most of its force, producing hailstones and high winds.

7. You can determine their presence by the occurrence of thunder, lightning, hail, or heavy showery precipitation.

8. Mammatus development appears pouchlike, whereas tubas are ragged cone-shaped appendages. Tubas indicate probable tornado activity.

9. L9 has a cirriform top (anvil). L3 lacks appreciable cirriform development.

10. Unlike TCU remarks, the cumulonimbus cloud remark includes a direction of movement and the distance from station, if known.

11. L9, cumulonimbus.

12. Stratocumulus clouds in detached elements have a flatter appearance than cumulus clouds.

13. L4 forms from the spreading out of cumulus clouds; L5 does not.

14. L8 is a combination of cumulus (L1 or L2) and stratocumulus clouds that coexist at different levels. The stratocumulus must not have formed from the spreading out of cumulus clouds.

15. The base of stratus clouds has a more uniform distribution of color; stratocumulus clouds have an unequal color distribution.

16. Stratus clouds produce only light precipitation (drizzle, etc.) and may reveal the sun through their thinnest parts. Nimbostratus clouds on the other hand are darker, do not reveal the sun, produce heavier precipitation, and have an uneven diffuse base.

17. L7 clouds appear darker and more ragged than L6 clouds; however, the main difference is that if there is bad weather (precipitation), the stratus clouds are encoded as L7.

18. When the sun is visible through altostratus, it appears as though seen through ground glass. This effect prevents objects on the ground from casting shadows.

19. Approximately 6,500 feet to 23,000 feet.

20. M2 clouds do not reveal the outline of the sun; M1 clouds may. M2 clouds often produce continuous precipitation, especially when nimbostratus clouds are present.

21. Darker.

22. If the size of the elements are such that they cover less than three fingers held at arm's length, the cloud type probably is altocumulus; if they cover more than the three fingers they are probably stratocumulus clouds.

23. A corona usually indicates the presence of semitransparent altocumulus clouds.

24. M3 clouds occur at a single level, and their elements change slowly. M4 clouds occur at one or more levels, and the elements are continually changing.

25. M5.

26. M6.

27. M7 clouds consist of either altocumulus clouds in two or more layers and not progressively invading the sky, or altocumulus clouds together with altostratus or nimbostratus clouds.

28. M8 may appear as small tufts or as a layer with small towers sprouting from it (castellanus).

29. M9, altocumulus of a chaotic sky.

30. Cirrus clouds.

31. Approximately 16,500 to 45,000 feet.

32. H1 clouds do not progressively invade the sky; H4 clouds do.

33. H3 clouds are the remains of a cumulonimbus cloud, and H2 clouds are not.

34. The primary difference between cirrus and cirrostratus is the greater horizontal extent of cirrostratus clouds and their more veil-like appearance.

35. A cirrostratus cloud is never thick enough to prevent objects on the ground from casting shadows when the sun is higher than 30° above the horizon. The sun also causes halo phenomena in the presence of cirrostratus clouds.

36. H6 clouds extend more than 45° above the horizon, and H5 clouds do not extend above 45°.

37. An H7 cloud (cirrostratus) must cover the entire sky.

38. When cirrostratus clouds are in patches (not cirrus), you can classify them as H8.

39. By the size of the elements. If an average element does not cover your little finger at arm's length when the cloud is 30° above the horizon, the cloud is cirrocumulus.

40. Cirrocumulus clouds must be predominant to be encoded H9.

41. These clouds are usually formed by a mountain wave condition which can also cause severe turbulence.

42. Standing lenticular (ACSL) and all rotor clouds.

43. Cloud type L5, stratocumulus.

44. 1964.

45. 107/ (whenever you have more than one cloud type in a division, you select the type that is most significant).

Section 2

1. To be a layer, clouds or obscuring phenomena must have horizontal bases at the same level.

2. Sky cover symbols represent the total sky covered at and below that level.

3. -⦷.

4. "43" and "120" respectively.

5. A ceiling is the height of the lowest layer of clouds or obscuring phenomena aloft that is reported as broken or overcast and is not classified as thin; or the vertical visibility in a surface-based obscuring phenomenon not classified as partial.

6. "M."

7. The ceiling designator "M" can be obtained from the known heights of objects such as radio towers within 1½ nautical miles of the airfield.

8. 18–⦶35–⦶R95⦷.

9. -X35⦶A130⊕.

10. The point at which the balloon first begins to fade from sight.

11. All forms of moderate precipitation except drizzle affect ceiling balloons and require the use of ceiling designator "E."

12. When the area is not mountainous or hilly, the clouds are formed locally, the clouds are at or below 5,000 feet, and recent dewpoint and free air temperature readings are available.

13. A ceiling represents vertical visibility into surface-based obscuring phenomena. The height of ceiling layers aloft represents the base of the layer.

14. W4X.

15. Column 3: M25V⦷ ; Column 13: CIG 22V29.

16. Enter ⌽V⌽ as a remark in column 13.

17. Column 13: ⊕46/1831 165⌽2001.

18. "BRKS W."

19. Column 13 contains a remark that reveals the phenomenon and its amount in tenths such as F3.

20. K40⌽.

Section 3

1. Dark objects.

2. Accumulation of ice or precipitation on lights and lack of contrast or sharpness at sunrise and sunset cause apparent reduction in visibility.

3. No. To report a "+" visibility, your estimated visibility must be twice the distance to the most distant marker.

4. 2½ miles.

5. First, sector visibility aids in determining the prevailing visibility; second, it points out sectors of the horizon where the visibility is significantly different from prevailing.

6. Current light setting.

7. The 1-minute value uses the current light setting, and the 10-minute value uses the highest available light setting.

8. Yes. RVR is reported when prevailing visibility is 1 mile or less, or RVR is 6,000 feet or less.

9. Because the prevailing visibility (average) is 3 miles and variable visibility is reported only when the prevailing visibility is less than 3 miles and the visibility varies by one or more reportable values.

10. VSBY NW13/4 NE2. The other sectors are omitted because SW represents prevailing and SE is 3 miles.

11. (1MR18VR14/12) R18VR10.

Section 4

1. Hurricanes are a special weather phenomenon distinguished from others by its large size. The storm encompasses so vast an area that its presence is obvious. Therefore, it is not reported as such on AWS Form 10. All the assoicated weather is reportable as individual elements.

2. A tornado.

3. "T+" because hail greater than 3/4 inch in diameter occurred.

4. Drizzle droplets are smaller, closer to each other, and appear to float as they follow air currents.

5. Precipitation is classified as "freezing" when liquid precipitation freezes upon impact with the surface or objects on the surface.

6. Ice pellets.

7. Hail is distinguished by its irregular shape and generally large size.

8. Snow pellets.

9. Snow grains are small and fairly flat or elongated in shape in comparison to the fuller branched development of snow.

10. Intermittent precipitation must stop and recommence at least once within the hour preceding the time of observation, whereas continuous precipitation does not stop during the preceding hour.

11. Showery precipitation.

12. Hail and ice crystals.

13. Visibility is the best method; however, when obstructions to vision occur with snow or drizzle, the rate of accumulation may be the only guide.

14. None. Only obstructions to vision that restrict the visibility to *less than 7* miles are reported.

15. Fog either reaches the base of the clouds or covers at least 0.6 of the sky. Ground fog covers less than 0.6 of the sky and never reaches the cloud bases.

16. Blowing snow restricts the visibility to less than 7 miles at eye level, whereas drifting snow does not.

17. Ice fog particles and ice crystals produce similar optical effects when observed through sunlight or other light sources.

18. Dust, blowing dust, blowing sand, haze, and smoke.

19. Dust.

20. Smoke at sunrise or sunset gives the sun a reddish coloring. During the daytime a slight reddish tinge may also be present.

21. FUNNEL CLOUD, T+, L, RW–. ZL, A, and F.

22. STATE POLICE TORNADO 15W OKC MOVG E 1610.

23. T B37 SW–W–N–E AND OVHD MOVG E PK WND 21/35 37.

    The location from the station for this particular remark can vary; for example, SW–NW–NE–E AND OVHD. However, usually the format that requires the least number of teletype characters should be used, provided you do not exceed 90° with any combination of direction points.

24. T B31E47 MOVD E PK WND 27/45 41 OCNL LTGCGCC E

25. AB35 HLSTO 1¼.

26. "INTMT R–" indicates that the precipitation has stopped and recommenced at least once in the past hour, whereas the remark "R–OCNLY R" implies a change in the intensity of continuous precipitation.

27. When the ground fog depth is less than 6 feet deep.

Sections 5, 6 and 7

1. Atmospheric pressure is defined as the pressure exerted by a column of air, of unit area, extended vertically from the reference surface to the top of the atmosphere.

2. Aneroid barometer, microbarograph, and mercurial barometer.

3. Station pressure is the atmospheric pressure at station elevation.

4. A new set of comparison readings must be accomplihsed as directed by FMH–1.

5. You must read the mercurial barometer every 6 hours to obtain a correction for the microbarograph, which is now the primary instrument.

6. Station pressure, 12-hour mean temperature, and station elevation.

7. He uses it to adjust his altimeter so that he can maintain a reasonably true altitude while in flight.

8. Sea-level pressure and altimeter setting.

9. "LOW 889." "LOW" is added when the altimeter setting is lower than 29.00 inches.

10. When the microbarograph is in use, an additional seven lines (59–65) on AWS Form 10 must be completed once every 6 hours.

11. Read pressure as close to the hour as possible, usually after all other elements are observed.

12. Station pressure to the nearest 0.005 inch of mercury is entered in column 17 once very 3 hours.

13. If the barograph is reset, place an asterisk before the "zero" correction and make a note in column 90 (*barograph reset to zero correction at 1410 LST).

14. The remark "PRESFR" indicates that the pressure is falling steadily at the rate of 0.06 inch per hour or more, whereas "LOWEST PRES" indicates that the pressure has fallen and then risen rapidly.

15. The Air Force uses a psychrometer or an automatic sensing hygrothermometer.

16. The temperature of the free air is sometimes referred to as the ambient temperature.

17. The dewpoint temperature.

18. Dewpoint, air temperature.

19. DP = 61.7. (The dewpoint is .7 of the way between 61 and 62 because the corresponding temperature is .7 of the way between 72 and 73.)

20. When the wet-bulb wick is covered with ice.

21. Enter the temperature as 23 and the dewpoint as 9.

22. Magnetic north.

23. The scale fitted above the pen indicates true direction.

24. The agonic line is a line along which true and magnetic direction are the same.

25. You may use a wind tee or cone to determine direction and use the Beaufort wind scale to determine the speed.

26. Gusts are identified by the symbol "G," followed with peak speed.

27. A squall is identified by the smbol "Q," followed with peak speed observed during the same 10 minutes.

28. Wind shift is a change in direction of 45° or more within 15 minutes.

29. 1918G24.

30. PK WND 27/37 46.

31. MAG.

32. Column 90 of AWS Form 10.

Sections 8 and 9

1. The primary objective of column 13 entries on AWS Form 10 is to record operationally significant information not reported elsewhere; to elaborate on preceding coded data; or to record 3- and 6-hourly synoptic data.

2. The first coded data in a surface observation for 3- and 6-hourly data is the barometric data (app 99ppp).

3. If you cannot use the barogram trace alone, you must select a code trace value (a) that is compatible with the pressure rather than the barogram trace. However, you should attempt to select a trace that maintains the approximate characteristics of the pressure over the past 3 hours regardless of this apparent discrepancy in pressure measuring instruments.

4. 299 99103.

5. 21212 ONE.

6. Enter "90499 90410" in column 13 following the cloud code group data.

7. Average the measurement of several areas, insuring that the maximum and minimum depths are included in these measurements.

8. The precipitation amount 0.47 inch would be coded as "30047."

9. Freezing levels from a raob balloon (RADAT), relative humidity at the middle coded height 84 percent; (019), height at which sounding first crosses 0° C isotherm is 1900 ft; (045), height of next to uppermost level at which sounding crosses 0° C isotherm is 4,500 ft; (051), height of uppermost level at which sounding crosses 0° C isotherm is 5,100 feet MSL; /1, indicator to show that one additional crossing of the 0° C isotherm occurred.

10. An icing level is present at 9,500 feet MSL over your station.

11. This column 13 entry indicates that there is loose snow on the runway (LSR), the runway condition reading is 15, and the runway has been sanded.

12. The four conditions that require weather modification remarks in column 13 are: (1) when they are about to take place, (2) when they are taking place, (3) when they have ended, and (4) when dispersal efforts may cease to affect the terminal weather.

13. Normally during the period in which DEFCON 3 or higher is declared.

14. Column 21 is the only summary column requiring hourly entries.

15. Column 42 time entries divide the observing day into 6-hour periods from midnight to midnight for the 6-hourly observations.

16. Column 68.

17. Precipitation, snowfall, and peak wind.

18. On the first page for each new day and when the weather sensor equipment is changed as a result of a change in active runway.

19. If the temperature is missing, enter an M in column 7.

20. Filing time is the time when you deliver your report to communications or transmit it yourself.

21. Correct the error by red-lining the incorrect entry and entering the proper data in red above the incorrect data on in column 13 with an identification. Then enter "COR" in red in column 13, followed by filing time.

CHAPTER 2

Section 10

1. Form 10.

2. Within 15 minutes of the last entry on your Form 10.

3. Hourly.

4. A 3-hourly observation contains the additional data of sea-level pressure and coded groups (app and $1C_LC_MC_H$).

5. The remark (TCU W–N) should be entered before the coded groups.

6. Take a special observation.

7. A special observation.

8. A special observation.

9. A special observation.

10. Take a special observation immediately. This special may be a single-element special and must describe the storm and provide the time and location of occurrence.

11. A special observation.

12. When the average 1-minute speed suddenly increases to twice, or more than twice, the currently reported 1-minute wind speed and exceeds 26 knots.

13. This observation does not contain mandatory special criteria and probably was recorded as a local observation because of established policies at the station (lowering of visibilities, ceiling, and appearance of ground fog). NOTE: At some stations this situation may be a criterion for a special based on local needs.

14. The observation at 1328 contains the first *mandatory* requirement for a special observation (visibility).

15. The observation at 1341 does not contain mandatory special criteria, but the lowering of cloud layers and/or visibility are likely local criteria for that station.

16. Clouds below 1,000 feet that were not previously reported and visibility lowered to below 2 miles.

17. There are two conditions that meet mandatory special criteria in this record special observation: the ceiling lowered below 3,000 feet and the beginning of precipitation other than very light.

18. Take a local observation immediately, including all columns of Form 10 that are needed for a record observation except sea-level pressure data. Disseminate the observation locally only and omit the contraction "ACFT MISHAP" from the transmission.

19. A local observation is required.

20. At locations where the local dissemination device does not provide a printed record, and the local observation contains only an altimeter setting.

21. The first coded elements of any pilot report are the location and the time of observation.

22. MKE–30W TOL.

23. You must be sure that the time is the time the phenomenon actually occurred and not the time you received it.

24. The PIREP is from Denver, Colorado, to Little Rock, Arkansas, and the report began at 1615 and terminated at 1902.

25. PIREP cloud heights are encoded in hundreds of feet MSL.

26. Several types are: tornadoes, funnel clouds, waterspouts, thunderstorms, and hail.

27. LGT, MDT, SVR, and EXTRM.

28. Severe clear air turbulence at 26,000 feet MSL; report by a C–5A aircraft.

29. LGT MXD ICG 45 T–29.

30. Turbulence and icing are both types of phenomena that can alter or influence the aerodynamic forces that act upon an aircraft. Certain types of aircraft are affected differently by these phenomena; therefore, it is helpful to know the type of aircraft.

31. 60⦶ 300U335 CONTRAILS 410 F–111.

32. When the aircraft is actually struck by electrical discharges in flight.

33. RAN PIREP 10SW RAN 1127 WND 270/45 80 LGT CAT 110–130 310⊜ F–110.

34. When tornado activity, severe or extreme turbulence, hail or heavy icing are reported, the encoded PIREP must be tansmitted longline as a warning (WO).

Section 11

1. Base operations, control tower, and GCA units are usually on the local dissemination list for observations.

2. FMH–1, AWS Form 10.

3. "ACFT MISHAP."

4. When speaking into an intercom system, you should talk at a moderate speed and speak very clearly.

5. When establishing your first contact on an intercom system, you should be sure to identify yourself.

6. Visibility *one* and *one* half.

7. When disseminating the altimeter setting, four digits are used.

8. South, *one* and *one* half.

9. After local dissemination the next priority is longline transmission.

10. The ADCAD/OWS teletype system consists of two paralleling eight-circuit networks.

11. The term "H-Time messages" is the automatic scanning by the programmer to collect hourly observations.

12. No. Because the ADCAD/OWS programmer transmits the stations TSC which causes the ADCAD-outstation code generator to generate SOM and automatically transmit in proper sequence.

13. The term "T-Time messages" is the automatic scanning by the programmer to collect special observations.

14. The term "special category traffic" is used to differentiate between special weather that must be collected on the OWS network, at specific times, and the routine data being relayed on this network.

15. The two types of SP traffic presently polled on the OWS network are SDUS - SP1 and TAFOR/PLATF - SP2.

16. TYPNO (OK) messages are transmitted on COMET II.

17. The mainland U.S. is divided into eight separate weather circuits.

18. AWSM 105–2, Volume 2, contains the listing of weather teletype bulletins.

19. The detachment commander.

20. It is outlined in black.

21. One type is a weather satellite chart.

22. Forecaster's.

Section 12

1. One of the prime purposes of weather radar observations is the early detection of hazardous weather phenomena.

2. When no echoes are observed, primary radar reporting stations must transmit the minimum of one radar observation, "PPINE," every hour.

3. When precipitation echoes or fine lines associated with meteorological discontinuities are present on the radar scopes.

4. Take a special radar observation.

5. That the echoes are in the shape of a broken line (6/10 to 9/10 coverage).

6. Use surface weather reports, visual observations, and PIREPs.

7. Reflectivity values provide a method of determining echo intensity.

8. Because of special problems involving reflectivity measurement, echo intensities are not reported for *ice pellets, freezing drizzle, drizzle, hail,* or *snow.*

9. When the echo systems that you are reporting are farther than 125 nautical miles from the station.

10. By using a trend of past reflectivity values.

11. To the nearest whole degree and nearest nautical mile.

12. By reporting as many direction and distance points as necessary to provide an approximate reproduction of the echo area when the points are connected.

13. Report cells or circular areas by giving the direction and distance to the center of each cell or area and the diameter (D) of the echo.

14. Report as many points as necessary to establish the axis of the line. Further identify the line by reporting the average width.

15. "12W" indicates that the average width of a line is 12 nautical miles.

16. Report the diameter. For example, "D15" equals a 15-mile diameter.

17. Echo system movement is obtained by using at least two successive positions 1 hour or more apart. For cells and small elements, determine the movement over a 15-minute interval if it is representative. Report the direction from which the echo is moving in tens of degrees and report the speed of movement to the nearest knot.

18. You cannot accurately determine the movement of the echo; therefore, enter a remark, such as PCPN AREA CNTRD THISTA, to explain this situation.

19 When scanning for echo top measurements, you must consider range limitations which vary depending on the type of radar being used.

20. To support and amplify other elements of the radar observation.

21. In the Remarks section as "MLTLVL," followed by the height in hundreds of feet MSL. For example, MLTLVL 67.

22. RHINO.

23. When a special RAREP is required at a nonscheduled transmission period, it must include the contraction "SPL" followed by a GMT time group. Otherwise, the "SPL" prefix is all that is required.

24. ABO SPL 1915Z PSBL FUNNEL CLOUDS 30W MOVG ENE.

25. Draw a red line through the incorrect entry and enter the correct value above it in red. When the correction is transmitted over teletype, enter "COR" and the GMT transmission time in red in the Remarks section.

MODIFICATIONS

Pages 39- 40 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

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STOP– 1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER. 2. USE NUMBER 1 PENCIL.

25251 02 26

VOLUME REVIEW EXERCISE

Carefully read the following:

DO'S:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, take action to return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that numerical sequence on answer sheet alternates across from column to column.
3. Use only medium sharp #1 black lead pencil for marking answer sheet.
4. Circle the correct answer in this test booklet. After you are sure of your answers, transfer them to the answer sheet. If you *have* to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if at all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If *mandatorily* enrolled student, process questions or comments through your unit trainer or OJT supervisor.
   If *voluntarily* enrolled student, send questions or comments to ECI on ECI Form 17.

DON'TS:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than with a #1 black lead pencil.

NOTE: The 3-digit number in parenthesis immediately following each item number in this Volume Review Exercise represents a Guide Number in the Study Reference Guide which in turn indicates the area of the text where the answer to that item can be found. For proper use of these Guide Numbers in assisting you with your Volume Review Exercise, read carefully the instructions in the heading of the Study Reference Guide.

Multiple Choice

Chapter 1

1. (200) The number of basic cloud forms generally used by meteorologists is

a. 3.	c. 10.
b. 7.	d. 27.

2. (200) Assume that you observe low, grey, ragged clouds; thick altostratus or nimbostratus clouds and light precipitation. Which cloud code group is correct?

a. 162/.	c. 172/.
b. 171/.	d. 161/.

3. (200) Which of the following options gives a correct comparison of cumulus and cumulonimbus clouds?

Cumulus	*Cumulonimbus*
a. Nonstratified top.	Anvil top.
b. Thunder and lightning.	Good weather.
c. Extensive vertical development.	Little vertical development.
d. Massive appearance.	Small appearance.

4. (200) When cumulus and stratocumulus (not from cumulus) appear together, you code them as

   a. C_L-8 if their bases are at different levels.
   b. C_L-2 if their bases are at different levels.
   c. C_L-2 and C_L-5 regardless of layers.
   d. C_L-2 because of order of encoding priority.

5. (200) Assume that you observe large massive low clouds with tops that lack clear outlines but no appreciable stratiform development, altocumulus clouds that appear to have formed from cumuliform clouds, and the cirriform remains of a cumulonimbus cloud. Which cloud code group is correct?

a. 1263.	c. 1363.
b. 1362.	d. 1963.

6. (200) One way to recognize cumulonimbus L3 from L9 is by the

   a. massive appearance of L9.
   b. occurrence of lightning or thunder with L9.
   c. fibrous top of L3.
   d. mammatus formation associated with L3.

7. (200) Which cloud types are present for a cloud code group of 147/?

   a. Stratocumulus from cumulus, altocumulus, and altostratus.
   b. Stratocumulus not from cumulus, altocumulus, and nimbostratus.
   c. Stratocumulus from cumulus and semitransparent altocumulus.
   d. Stratocumulus not from cumulus and cirrostratus covering entire sky.

8. (201) Which cloud types are present for a cloud code group of 1838?

   a. Cumulus, stratocumulus not from cumulus, semitransparent altocumulus, changing slowly, and patches of cirrus.
   b. Cumulus, stratocumulus from cumulus, semitransparent altocumulus, changing rapidly, and patches of cirrostratus.
   c. Cumulus, stratocumulus not from cumulus, semitransparent altocumulus, changing slowly, and patches of cirrostratus.
   d. Cumulus, stratocumulus from cumulus, semitransparent altocumulus, changing slowly, and patches of cirrostratus.

9. (201) When the sun appears dimly visible as though seen through ground glass, the cloud type affecting the view is

   a. cirrostratus, C_H-7.
   b. stratus, C_L-6.
   c. altostratus, C_M-2.
   d. altostratus, C_M-1.

10. (201) Altocumulus clouds, C_M-8, appear as either

    a. altocumulus or altocumulus together with altostratus.
    b. rounded masses or bands.
    c. tufts or small towers.
    d. patches or lenticular shaped.

11. (201) Cirrus and cirrostratus clouds differ primarily because of the

    a. more veil-like appearance of cirrostratus clouds.
    b. darker appearance of cirrostratus clouds.
    c. thinner composition of cirrus clouds.
    d. greater horizontal extent of cirrus clouds.

12. (201) The difference in classification between high clouds 6, 7, and 8 is that

    a. H8 is cirrostratus, H6 and H7 are cirrus.
    b. H6 is invading, H7 and H8 are not.
    c. H7 is semitransparent, H6 and H8 are dense.
    d. H8 covers the entire sky, H6 and H7 do not.

13. (201) Select the statement which best describes orographic clouds.

    a. A rotor cloud remains stationary.
    b. Foehnwall is cumuliform in appearance.
    c. Orographic clouds indicate stability.
    d. A lenticular cloud resembles a "mackerel" sky.

14. (201) Which of the following is characteristic of lenticular clouds?

    a. Usually opaque.
    b. Continually changing in appearance.
    c. Found at a single level.
    d. Dissipated quickly by high winds.

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15. (202) Each sky cover symbol represents that portion of the sky covered

a. at that level and above.
b. at that level and below.
c. below that level only.
d. at that level only.

16. (202) Suppose that the lowest layer covers 2/10 of the sky, the second layer covers another 4/10 but is 3/10 thin, and the highest layer covers the entire sky. What is the correct entry for column 3 of AWS Form 10?

a. ⦶, ⦷, -⦷.
b. ⦶, -⦷, ⊕.
c. ⦶, ⦷, ⦷.
d. ⦶, -⦷, -⊕.

17. (202) Select the correct column 3 entry 2/10 surface-based obscuring phenomena, 0/10 cumulus at 2,800 feet, 3/10 smoke layer at an estimated 4,500 feet, and a solid overcast measured by TPQ–11 radar at 12,000 feet.

a. -X28⦶R120⊕.
b. -X28⦶E45⦷120⊕.
c. -X45⦶R120⊕.
d. -X28⦶45⦶R120⊕.

18. (202) Suppose that you have the sky partly obscured by 6/10 fog and 2/10 of clouds are visible also. What is the correct symbols for column 3 of AWS Form 10?

a. -X -⦶.
b. -X ⦶.
c. -X -⦷.
d. -X ⦷.

19. (203) A large tower 1 1/16 miles from the airfield reveals the base of the clouds to be 250 feet. What column 3 entry should you make on AWS Form 10 if the layer is overcast?

a. E3⊕.
b. E2⊕.
c. M3⊕.
d. M2⊕.

20. (203) Your FPS–77 radar reveals the base of the clouds to be 21,300 feet. What column 3 entry should you make on AWS Form 10 if the layer is 9/10 coverage?

a. E220⦷.
b. R220⦷.
c. R210⦷.
d. E210⦷.

21. (203) Suppose that 10 minutes ago within ½ mile of the runway, an aircraft reported the ceiling height at 2,500 feet, 6/10 coverage. You obtain a balloon ceiling height for the same layer at 2,900 feet. How should you report the ceiling?

a. E27V⦷.
b. A25⦷.
c. E27⦷.
d. B29⦷.

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22. (203) *Situation:* An aircraft flying over the runway within ¾ miles and 10 minutes from observation time reports the vertical visibility as 1,500 feet. The whole sky is covered by snow; however, 3/10 of the sky is visible through the snow in the SE. How should you report this condition in columns 3 and 13 of AWS Form 10?

Column 3	*Column 13*
a. -X	S7
b. A15X	none
c. W15X	S7
d. W15X	none

23. (203) Suppose that the ceiling is fluctuating rapidly between reportable values of 1,300, 1,500, 1,600, and 1,200 feet. Which Form 10 entry is correct?

Column 3	*Column 13*
a. V14V⊕	CIG VRBL
b. M13V⊕	CIG VRBL
c. M14V⊕	CIG 12V16
d. M13V⊕	CIG 12V16

24. (203) *Situation:* The present sky condition is 5/10 cumulus at a measured 2,500 feet and an estimated 7,500 feet overcast. The first layer occassionally becomes broken and you can see higher clouds through breaks in the overcast. How should you report this situation on Form 10?

Column 3	*Column 13*
a. M25 ⦷ 75⊕	⦷V⦶ HIR CLDS VSB
b. 25 ⦶ E75⊕	⦶V⦷ BINOVC
c. M25 ⦶ E75⊕	⦶V⦷ HIR CLDS VSB
d. M25 ⦷ 75⊕	⦷V⦶ BINOVC

25. (204) Which of the following options is *not* a reportable visibility value?

a. 5/16.
b. 7/10.
c. 1 7/8.
d. 3/8.

26. (204) When is RVV reported in all observations?

a. Whenever the prevailing visibility is 1 mile or less and the RVR is 1 mile or less.
b. Whenever the prevailing visibility is 1 mile or less and your station does not report RVR.
c. Whenever the prevailing visibility is 2 miles or less.
d. Whenever the prevailing visibility changes by a reportable value.

27. (204) When is RVR reported in all observations?

a. For every change in reportable value.
b. Whenever prevailing visibility and RVR is 1 mile or less.
c. Whenever prevailing visibility is 1 mile or less, or RVR is 6,000 feet or less.
d. Whenever prevailing visibility changes by reportable value.

28. (204) Which of the following options is the correct way to report variable visibility in column 4 and column 13 of AWS Form 10?

Column 4	*Column 13*
a. V 1¼	VSBY 1V2
b. 1¼	VSBY 1V2
c. 1¼ V	VSBY 1V2
d. 1¼ VAR	VSB 1V2

29. (204) Which of the following options is correct for entering sector visibility in column 13 of AWS Form 10?

a. VSB E thru NNW 1½.
b. VSB E-S-W 5.
c. VSBY E 1½ S2 1/8.
d. VSBY SE 1½ S1.

30. (205) Of the following weather phenomena, which can be used as a definite guide for determining the presence of a severe thunderstorm (T+)?

a. ¾-inch hail.
b. 35-knot winds.
c. Frequent thunder.
d. Mammatus development.

31. (205) Which descriptive term does *not* apply to the corresponding solid precipitation form?

a. Snow grains–refrozen.
b. Snow–branching.
c. Ice crystals–unbranched.
d. Snow pellets–crisp.

32. (206) Which of the following entries in column 5 of AWS Form 10 *incorrectly* shows obstructions to vision?

a. 5 RW.
b. 6 L-.
c. 7 H.
d. 5 BS.

33. (206) Which of the following examples illustrates the correct order of entry for weather and obstructions to vision in column 5 of AWS Form 10?

a. T, L-, ZL-, SG+, F.
b. T, RW-, SG+, ZL, -F.
c. T, RW, F, S-.
d. T, ZR, R-, SG-.

34. (206) Which of the following examples of column 13 significant remarks is *incorrect*?

a. TORNADO B53 W MOVG NE PK WND 27/85 58.
b. WATERSPOUT E56 MOVD E PK WND 30/37 51.
c. UNCONFIRMED FUNNEL CLOUD 20W CLL MOVG E 1920.
d. STATE POLICE REPORTED POSSIBLE TORNADO 8 MILES WEST OF FWH MOVG EWD AT 1930 GMT.

35. (206) How many significant remark contractions are there for the types of lightning?

a. 3.
b. 4.
c. 5.
d. 6.

36. (206) Which example shows the correct usage of a significant remark for hail?

a. HAIL B35 HLSTO 1¼.
b. HAIL B35 1¼ DIAMETER.
c. AB35 HLSTO 1¼ DIAMETER.
d. AB 35 HLSTO 1¼.

37. (206) Which example shows the correct usage of a significant remark?

a. INTMT RW–.
b. SNOINCR 1.
c. OCNL R–.
d. RW–OCNLY RW.

38. (207) When can a new aneroid barometer be used?

a. After 1 week of checking readings against some standard.
b. After being calibrated by the field maintenance shop.
c. After comparing readings with the mercurial barometer in accordance with FMH–1.
d. After 2 weeks of checking temperature zone that the aneroid is located.

39. (207) Station pressure, though not transmitted, is recorded in column 17 of AWS Form 10 once every hour to the nearest

a. .001 inch of mercury.
b. .005 inch of mercury.
c. .010 inch of mercury.
d. .001 millibar.

40. (207) When the barograph is reset, it should be shown on AWS Form 10 by placing an asterisk before the "ZERO" correction and making a note in column

a. 59.
b. 65.
c. 72.
d. 90.

41. (207) If the pressure trace on a barogram shows a rapid fall of 0.06 inch per hour, the significant remark made in column 13 of AWS Form 10 to indicate this situation is

a. PRESRR.
b. PRJMP.
c. PRESFR.
d. PRES UNSTDY.

42. (208) A temperature of 10 below zero is recorded in column 8 of AWS Form 10 as

a. minus 10.
b. 10 below.
c. minus ten.
d. -10.

43. (208) After obtaining your local magnetic variation, you may convert magnetic direction to true direction by

a. subtracting easterly variation from magnetic direction.
b. subtracting westerly variation from magnetic direction.
c. adding westerly variation to magnetic direction.
d. adding easterly variation to true direction.

44. (208) Which of the following is an example of gustiness?

a. 10Q20.
b. 15Q37.
c. 10+30.
d. 12G35.

45. (208) Suppose that the duty forecaster informs you of frontal passage at 1318 GMT. Which is the correct column 13 entry?

a. WND SHFTG GRDLY.
b. WSHFT 1318 FROPA.
c. WSHFT 1318.
d. WSHFT FRONPA.

46. (208) Which of the following is an encoded wind at 105 KTS from 160°?

a. 1605 one hundred.
b. 1605 one.
c. 16105.
d. 6605.

47. (208) A peak wind of 37 knots from 270° at 1146 GMT is recorded in column 13 of AWS Form 10 as

a. Peak Wind 37/37 1146.
b. PK WND 27/37 1146.
c. PD WND 37/37 46.
d. PK WND 27/37 46.

48. (209) Suppose that you have determined that the pressure barometric characteristic is "8" and the coded tendency is "117." How is this data entered in column 13 of AWS Form 10 if the 6-hourly liquid precipitation was 1.37 inches?

a. 89937 99117 ONE.
b. 89937 ONE 99117.
c. 899 9911799137.
d. 899379913799117.

49. (209) How is a snow depth of 118 inches encoded in column 13, AWS Form 10?

a. 90418 ONE.
b. 90499 99118.
c. app18 ONE.
d. 90499 90418.

50. (209) How is a 24-hour precipitation of 2.38 inches encoded in column 13, AWS Form 10?

a. 24238.
b. 20038 TWO.
c. 20238.
d. 24038 TWO.

51. (209) The third digit for RADAT code is

a. the relative humidity at the first crossing of the 0° C. isotherm.
b. the height of the first freezing level.
c. a letter designator identifying the 0° C. isotherm crossing to which the coded value of UU corresponds.
d. an indicator group used to show the number of crossings of the 0° C. isotherm other than those heights are encoded.

52. (209) Which additional data remark indicates that slush is on the runway, patchy runway conditions, and a runway condition reading of 15?

a. LSR15P.
b. LSRP15.
c. SLRP15.
d. SLR15P.

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53. (209) If you are assigned to weather unit within the CONUS or Alaska, when are you normally required to transmit radiation intensity data?

a. Once every 12 hours.
b. Once a day at 0900 GMT.
c. Under specified conditions; usually during the period in which DEFCON 4 or higher is declared.
d. Under specified conditions; usually during the period in which DEFCON 3 or higher is declared.

54. (210) Which column on AWS Form 10 summarizes total sky cover for each record observation?

a. Column 3.
b. Column 13.
c. Column 21.
d. Column 90.

55. (210) Suppose that at a 6-hourly observation, you measure a 3-inch snowfall (.35-inch melted equivalent) during the past 6 hours. The proper precipitation and snowfall summary entries for AWS Form 10 are:

Column 44	*Column 45*
a. .35	no entry.
b. .35	3.0
c. 3.0	.35
d. no entry.	3.0

56. (210) How is a 24-hour snowfall (unmelted) of 3 inches entered on AWS Form 10 and in which column is it entered?

a. Column 69–3.0.
b. Column 68–3.
c. Column 70–3.
d. Column 70–3.0.

57. (210) In which column of AWS Form 10 are active runway and equipment changes recorded?

a. Column 13.
b. Column 21.
c. Column 70.
d. Column 90.

Chapter 2

58. (211) All elements of a record observation must be observed within how many minutes of the last AWS Form 10 entry for the observation?

a. 10.
b. 15.
c. 20.
d. 25.

59. (211) The 6-hourly observations are recorded at

a. 0000, 0600, 1200, and 1800 LST.
b. 0000, 0600, 1200, and 1800 GMT.
c. 0300, 0900, 1500, and 2100 LST.
d. 0300, 0900, 1500, and 2100 GMT.

60. (211) Which change in visibility requires a special observation?

a. 1¾ miles of visibility becomes 1½ miles.
b. 2 miles of visibility becomes 3 miles.
c. 3 miles of visibility becomes 5 miles.
d. 10 miles of visibility becomes 3 miles.

61. (211) Which of the following is *not* a criterion for taking a special observation?

a. Thunderstorm stops.
b. Freezing precipitation begins, ends, or changes in intensity.
c. Wind direction changes 35°, and takes place in less than 15 minutes.
d. Tornado is reported by the State police 1 hour ago.

62. (212) Suppose that you are notified at 1030L to take an observation for an aircraft mishap. How is the report disseminated?

a. Locally, but without the contraction "ACFT MISHAP."
b. Longline and locally, but without the contraction "ACFT MISHAP."
c. Locally, using the Form 10 columns normally entered for a local.
d. Longline as a special.

63. (212) Which example shows the correct format for encoding the location or extent of phenomena for a pilot report from 40 nautical miles south of EAU to MKE from 1116Z to 1230Z?

a. 40S EAU–MKE 1116–1230.
b. EAU 40S–MKE 1230.
c. 40S EAU–MKE 1230.
d. EAU 40S–MKE 1116–1230.

64. (212) Which of the following is *not* a criterion for requiring a local observation at a weather station?

a. Ice pellets change intensity.
b. Altimeter settings are required at the station at a frequency not to exceed 35 minutes.
c. ACFT MISHAP.
d. The 1-minute mean RVR criterion is first met.

65. (212) Which element of a record observation is *not* included in an "ACFT MISHAP" local observation?

a. Temperature.
b. Altimeter setting.
c. Sea-level pressure.
d. Dewpoint.

66. (212) Which is a correct statement concerning the AWS Form 12, Pilot Report?

a. The forecaster must review each report before transmission.
b. The forecaster is responsible for making AWS Form 12 entries.
c. The DETCO must certify all hazardous weather (WO) PIREPs prior to transmission.
d. All times are entered in local time.

67. (213) Local dissemination procedures are based on the requirements listed in

a. AFCSR 105–1.
b. AFCSR 105–2.
c. FMH–1.
d. FMH–3.

68. (213) When establishing your first contact on an intercom system, you should be sure to do all of the following *except* to

a. report rapidly.
b. speak very clearly.
c. identify yourself.
d. talk at a moderate speed.

69. (213) What type of weather message is transmitted in H-time polling cycles?

a. Storm observations.
b. Special observations.
c. Local observations.
d. Hourly observations.

70. (213) Which of the following should be classified as special category traffic?

a. PIREP.
b. Tornado.
c. SDUS.
d. Hail.

71. (213) The mainland of the U.S. is divided into how many weather circuits?

a. 6.
b. 8.
c. 10.
d. 12.

72. (213) Processing of satellite charts is usually a function of the

a. observer.
b. forecaster.
c. DETCO.
d. maintenance technician.

73. (214) If you are at a primary radar reporting station, what transmission should you make when no echoes are on the radar scope at the hourly observation time?

a. PPINE.
b. PPIOM.
c. PPINO.
d. ROBEPS.

74. (214) When an echo is over or nearly over the station and you can *not* identify its position because of precipitation attenuation and ground clutter, how, if at all, should you report the echo?

a. Indicate its presence in remarks only.
b. No entry.
c. Report it at a position compatible with previous trends of movement.
d. 000/00.

75. (214) When determining intensity trend for a *line of echoes*, the minimum time period to use is

a. 10 minutes.
b. 15 minutes.
c. 30 minutes.
d. 60 minutes.

76. (214) Which statement concerning the reporting of radar observations is *not* correct?

a. Irregular areas are identified by as many direction and distance points as needed.
b. Direction and distance points are reported consecutively in a clockwise direction.
c. Large circular areas are identified by reporting the center position and diameter of the area.
d. Direction and distance points for echo lines are limited to the two end points on the axis of the line.

77. (214) Determine the speed of movement of a radar echo system on the basis of at least

a. two successive positions 1 hour or more apart.
b. one position 1 hour or more apart.
c. two successive positions 15 minutes or more apart.
d. one position 15 minutes or more apart.

78. (214) Assume that you observe a bright band on the RHI scope with the base at 6,500 feet and the top at 7,300 feet MSL. How should you encode it?

a. MLTLVL 65.
b. MLTLVL 73.
c. BRIGHT BND 65.
d. BRIGHT BAND 73.

79. (214) Which coded RAREP is correct for reporting an anticipated 12-hour equipment outage at Rawtoul (RAW) if the current time is 0640Z on the 9th and the alternate station is Grissom AFB (GUS)?

a. RAN PPIOM 091840Z ALTN GUS.
b. RAN PPIOM ALTN GUS 090640Z.
c. RAN PPINA 091840Z ALTN GUS.
d. RAN PPINA ALTN GUS 090640Z.

Chapter 3

80. (215) Which AWS regulation is the numerical index for all AWS manuals?

a. 0–2.
b. 0–4.
c. 0–6.
d. 0–8.

81. (215) In accordance with AFR 5–31, *Air Force Publications Reference Systems*, changes and supplements are filed in

a. front of the volume to which it pertains.
b. back of the volume to which it pertains.
c. front of the blank pages at the back of the book.
d. back of their basic publication.

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MODIFICATIONS

Pages 53-54 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

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CDC 25251

WEATHER OBSERVER

(AFSC 25251)

Volume 3

Weather Plotting and Communications

15-1

Extension Course Institute
Air University

CHANGES FOR THE TEXT: VOLUME 3

iv		7	Change currency date to "April 1974."
1	1-1	14	Change "US Weather Bureau" to "National Weather Service."
1	1-2	7	Change "are surface chart" to "area surface chart."
6	1-30	4	Change "ohe" to "the."
7	1-40	17	Change "blobe" to "globe."
9	1-46	4	Change "four" to "three."
10	1-56	7	Change "snow showersshowers" to "snow showers."
10	1-59	7	Change "clous" to "cloud."
19	2-26	1	Change "solid" to "solidi."
26	2-67, Col 2	11, 12	Change "addepted" to "adopted."
27	2-75	7	Change "schedules" to "scheduled."
34	Text table, Encoded Data column		Delete "Z" from "0204Z" and "0249Z."
36	3	4	Change "award" to "aware."
36	3	17	Change "satelliet" to "satellite."
36	4-3	2	Change "Netwoek" to "Network."
37	4-5	11,15	Delete remainder of sentence beginning with Tinker Weather, etc." Replace with "Carswell Automatic Digital Weather Switch (ADWS), Automated Weather Network (KWAN) located at Carswell AFB, Texas."
37	4-6		Delete and replace with new paragraph 4-6.
			"4-6. The COMET system establishes a method of collecting and disseminating weather data for

TABLE 17

CLASSIFICATION OF ECHOES

CHARACTER	CONTRACTION	DEFINITION
Cell	CELL	A single convective echo that for reasons for spatial isolation or character individuality cannot be grouped with other echoes.
Area	AREA	Related or similar echoes that can be readily associated geographically for reporting purposes. Echoes must cover at least 5 percent of the total area of the system being reported, and in the case of a convective area more than three cells are required to make an area.
Line	LN	Related or similar echoes that form into a pattern exhibiting a length to width ratio of at least five to one and a length of at least 30 nautical miles. At least 30 percent of the total area of the system being reported must be covered by weather echoes. If the line pattern forms within an existing echo system it should persist for at least 15 minutes or should be at least 60 percent covered by weather echoes before being identified as a line.
Stratified Elevated Echo	LYR	Precipitation aloft. In this case the height of both the top and base of the echo will be reported.
Spiral Band Area	SPRL BAND AREA	Echoes associated with tropical storms, hurricanes, or typhoons and systematically arranged in curved lines. This grouping may include a wall cloud.
Fine Line	FINE LN	Narrow nonprecipitation echo pattern associated with a meteorological discontinuity such as the cold air outflow in advance of a squall line or the leading edge of a sea breeze.

TABLE 19

INTENSITY RELATIONSHIP

Symbol	Estimated Precipitation	Echo Intensity	Theoretical rainfall rate in./hr.*
-	light	weak	< 0.1
	moderate	moderate	0.1-0.5
+	heavy	strong	0.5-1.0
++	very heavy	very strong	1.0-2.0
X	intense	intense	2.0-5.0
XX	extreme	extreme	> 5.0

*Based on the relationship $Z = 200R^{1.6}$

Page	*Paragraph*	*Line(s)*	*Correction*
			military weather reporting stations. A computer is the key to the operaton of COMET I and II circuits. The computer located at Carswell AFB, Texas, controls the switching and control function of COMET I and COMET II circuits. To better understand how the computer affects the military communications system, let's examine the operation of Comet I first."
37	4-7	2, 3, 7, 11, 12	Delete "ADCAD programmer" and insert "computer."
37	4-9	6, 8	Delete "programmer" and insert "computer."
37	4-11	8	Change "(KAWN)" to "(AWN)."
39	4-21		Add to display dot items: "• MWTCS, Kansas City, Kansas."
40	4-33		Delete fourth display dot and entire line beginning "Charleston. . . ."
44	6-11		Delete entire paragraph except for italic heading and insert: "Volume 2 is the master manual describing the meteorological message content (teletype and facsimile) of all bulletins originated by AWS activities. The volume is divided into four parts, as described below: Part I—General teletype messages. Part II—CONUS facsimile products. Part III—European facsimile products. Part IV—Pacific facsimile products."
45	6-12	5, 9	Delete comma after "alphabetically." Insert "in." Put a period after "Volume II." Delete lines 6 thru 8. Delete "II" at beginning of line 9.
48	6-31	14	Change "theregy" to "thereby."
48	6-32	9	Change "rochetsonde" to "rocketsonde."
48	6-37	9	Change "FLATF" to "PLATF."
49	6-41	5, 6, 7, 8	Delete entire sentence beginning with "When the COMET. . . ."
49	6-42	8	Between the words "local AT&T," insert "AFCS TCF. The TCF then notifies the local. . . ."
49	6-42	10	Delete "KWRF" and insert "KAWN."
49	6-44	2, 7, 10, 15	Delete "KWRF" and insert "KAWN."
50	6-47	1, 9	Delete "KWRF" and insert "KAWN."
50	6-48	2	Delete "KWAF" and insert "KAWN."
51	7-8	9	Change "he" to "The."
52	7-10	12	Change "waster" to "wasted."
52	7-13	6	Change "and the give" to "and then give."
53	7-18	10	Change "satisy" to "satisfy."

Preface

THIS VOLUME contains information to broaden your knowledge of weather plotting and communications. The centralized concept of operation has eliminated the need to plot charts on a massive scale at the detachment level. High-speed computers and data-handling machines have improved the timeliness and quality of weather charts. However, machines are not immune to malfunctioning. A prolonged facsimile outage could cause an increase in local chart preparation. In your job as a weather observer, you must be able to decipher the weather codes and plot the required weather charts. This volume also covers the communications function at the detachment level and explores the weather communications systems and electronic data processing provided at weather relay centers.

Chapter 1 is devoted to weather codes and how they are deciphered. Through the use of hypothetical situations, this chapter explains how you can determine the availability of the various weather reports for specified geographical areas. This discussion leads to the practical application of this knowledge: map plotting. The discussion of map plotting illustrates the variations in the plotting model and code type as the desired analysis changes. The chapter presents each weather code in its common plotting form and usage. Section 2 of Chapter 1 is devoted to upper air codes. This discussion acquaints you with the problems associated with decoding both radiosonde code and the upper wind codes. Emphasis is placed upon plotting requirements; however, special plotting requirements and charts are also discussed. Section 2 also discusses the three types of aircraft codes—RECCO, COMBAR and AIREP—that are plotted on weather maps and charts. Each code is discussed separately, with special emphasis placed on the plotting models most frequently used at a map plotting activity.

Chapter 2, Weather Communications and Editing, contains a comprehensive discussion of the communications tasks involved in the long-line dissemination of weather data. This chapter also gives you an insight into the operation of the various weather networks and weather relay centers. Chapter 3, Electronic Data Processing, contains a basic discussion of the operations in electronically processing and evaluating of weather data. It also gives the fundamental steps in programming and operating electronic data processing machines for a weather program. The chapter concludes with a discussion of tape maintenance and management. It also describes supervision and quality control.

Foldouts 1 through 9 are included in the supplement to this volume. Whenever you are referred to one of these foldouts in the text, please turn to the supplement and locate the foldout.

Code numbers appearing on figures are for identification by the preparing agency only.

If you have questions on the accuracy or currency of the subject matter of this text, or recommendations for its improvement, send them to Tech Tng Cen (TTOC), Chanute AFB IL 61868.

If you have questions on course enrollment or administration, or on any of ECI's instructional aids (Your Key to Career Development, Study Reference

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Guides, Chapter Review Exercises, Volume Review Exercise, and Course Examination), consult your education officer, training officer, or NCO, as appropriate. If he can't answer your questions, send them to ECI, Gunter AFB AL 36118, preferably on ECI Form 17, Student Request for Assistance.

This volume is valued at 27 hours (9 points).

Material in this volume is technically accurate, adequate, and current as of December 1971.

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CHAPTER 1

Plotting Weather Charts

MOST WEATHER stations are involved to some degree in the decoding and plotting of weather codes. Naturally, if you are assigned to a weather central, you plot a greater variety of weather charts than the weather observer at a small detachment. No matter where your assignment may take you, an important part of your duties involves plotting weather charts and diagrams. You are expected to produce plotted charts that represent the various aspects of weather to the forecaster. His success in providing high-quality forecast service depends upon your speed, skill, accuracy, and initiative. These same qualities determine your success and progression in AWS. A thorough knowledge of the weather codes and proficiency in plotting them insures the forecaster's success as well as your own.

2. The codes discussed in this section are those that you most frequently encounter as an observer. The objective of this discussion is not to emphasize encoding or decoding of individual elements, but rather to illustrate what these codes represent in terms of their contribution to mission effectiveness. The symbolic forms and coding procedures for most of these meterological codes were presented quite thoroughly in the ABR25231 (resident) course. Your ability to encode, decode, and plot the data depends primarily upon the amount of practical experience you have in using any given code.

3. This chapter covers the surface weather codes used within the U.S. and internationally. It presents each code form in enough detail to refresh your memory of map plotting rules and policies. This chapter also includes the data normally plotted on a local area surface chart. Also, emphasis is placed on plotting severe weather advisories, radar reports, and pilot reports.

4. Although there are very few stations where you can be assigned that encode synoptic reports, there are many assignments that may require their plotting. However, to thoroughly learn the code, you should understand the encoding instructions. Therefore this discussion deals with how synoptic reports are encoded.

1. Surface Charts

1-1. Surface charts are necessary in any comprehensive analysis and forecasting program. The surface chart shows variations in weather conditions at the earth's surface. The forecaster is confronted with many more variables when making a surface analysis than when making an upper air analysis. Geographical influences, unequal surface heating, and unequal moisture distribution are only a few of the problems a forecaster must consider. The analysis of the weather data depicted on surface charts is basic to any forecasting service and is not limited to strictly professional agencies such as the Air Weather Service and the U.S. Weather Bureau. Broadcasters on television and radio also use the surface weather chart (weather map) to present weather conditions and forecasts to their viewers.

1-2. Surface charts are plotted on various map-scale sizes. Some charts cover the entire Northern Hemisphere (small-scale, large geographical area). Some cover only North America. Others cover a larger map-scale size (smaller geographical area) such as the local are surface chart (LASC) or local area work chart (LAWC). Because of the smaller scale of the larger area chart, fewer reports can be plotted for a given area. For instance, two or three station plots could easily cover the entire southern portion of Japan, whereas an LASC or LAWC of Japan would permit plotting many more stations over the same area. Therefore, it is important to plot the reports accurately on these smaller scale charts. Later this section discusses local area charts as a form of surface chart, but first let's discuss land synoptic codes.

1-3. **Land Synoptic Code.** The most detailed description of the various synoptic codes and the coding of the individual elements is contained in the *Federal Meteorological Handbook No. 2* (FMH2).

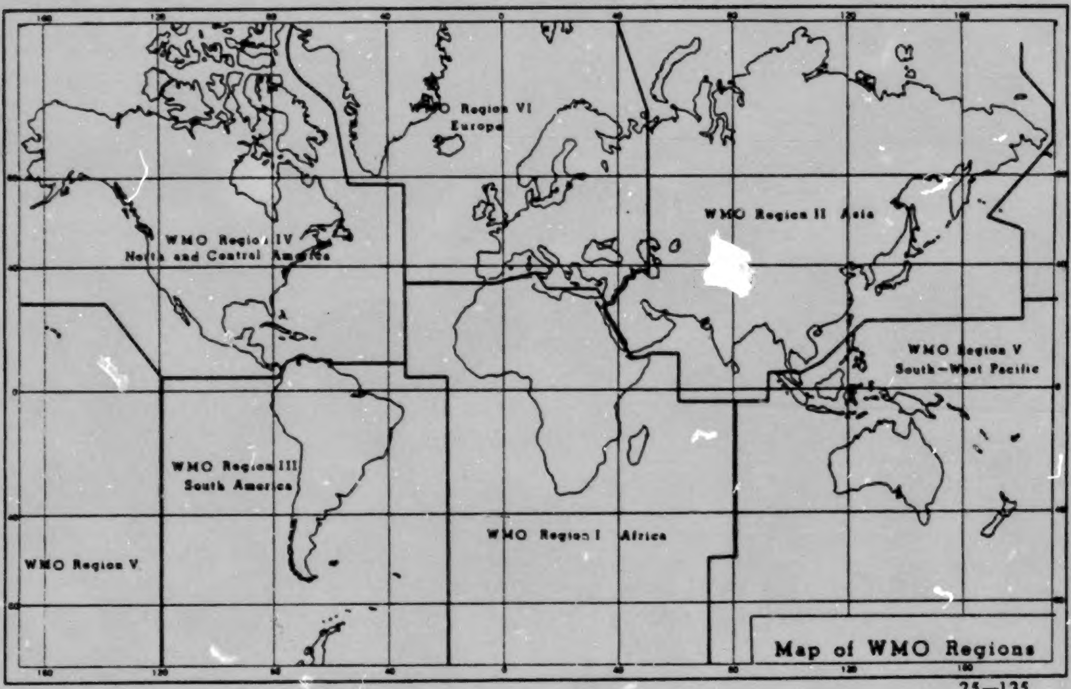

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Figure 1.

1-4. First you should understand the groups of synoptic code that are the same everywhere and the groups that have regional differences. Figure 1 shows the six World Meteorological Organization (WMO) regions which have regional differences in the code. You must be aware of these differences in order to decode correctly the synoptic code.

1-5. **Mandatory Groups.** Turn to foldout 1 (this foldout, along with others, is shown in the supplement to this volume), plotting guide synoptic code, and you can follow the symbolic form at the top of the page as we discuss each element. The *first six groups are mandatory* for all regions. After the first six, the groups *may or may not* be encoded depending on regional requirements. The groups which have the symbolic letter "j" have the most regional variations. Therefore, you should pay particular attention to them in the individual discussion of each group.

1-6. *Index number (IIiii).* Each synoptic reporting station reports the block number (II) followed by the station number (iii). For example, the block number "72" is assigned to the U.S. and the station number for Green Bay, Wisconsin, is 645. Therefore, the index number for Green Bay, Wisconsin, in synoptic code is "72645." Immediately following the index number is the sky cover and wind group.

1-7. *Sky cover and wind group (Nddff).* The first digit of this group (N) is the fractional part of the sky (celestial dome) in eighths that is covered by clouds. Table 1 shows the relationship between the code figure (N) and the fraction covered in tenths converted to oktas (eighths).

1-8. The wind direction (dd) is the direction from which the wind is blowing and is reported with respect to true north and to the nearest 10°. If the winds are calm, "00" is reported, and if they are missing or unobtainable, "//" is reported. At this point it seems worthwhile to mention that a solidus (/) is reported for missing or unobtainable data in synoptic code. This is true for all groups.

1-9. The windspeed (ff) is usually reported in knots. Windspeeds from 0—99 knots are reported without a conversion. For example, a windspeed of 99 knots is encoded "99." When windspeeds exceed 99 knots, "50" is added to the wind direction and 100 subtracted from the windspeed. For example, a wind from 140° (remember, you use only the first two digits, hence, 14) at 147 knots is encoded "6447." When interpreting synoptic reports, remember that some places in the world use meters per second (mps) rather than knots for windspeed. In this case, use a conversion table such as table 2 to convert windspeed from mps to knots.

TABLE 1
SKY COVER AMOUNTS

Symbol N = Fraction of the Celestial Dome Covered by Cloud

Symbol N_h = Fraction of the Celestial Dome Covered by All the C_L (or C_M) Cloud present

Symbol N_s = Fraction of the Celestial Dome Covered by an Individual Cloud Layer or Mass

Code Figure	Fraction Covered in Tenths	Fraction Covered in Oktas
0	Zero - - - - - - - - - -	Zero
1	1 or less but not zero-	1 Okta or less but not zero
2	2 and 3- - - - - - - -	2
3	4- - - - - - - - - - - -	3
4	5- - - - - - - - - - - -	4
5	6- - - - - - - - - - - -	5
6	7 and 8- - - - - - - -	6
7	9 or more, but not 10-	7 or more, but not 8
8	10 - - - - - - - - - - -	8
9	Celestial dome obscured, or cloud amount can not be estimated.	

1-10. *Visibility and weather (VVwwW).* The visibility (VV) is a coded value that readily converts to kilometers. It can also be converted to statute miles or yards. Land stations use the coded values "00" to "89," whereas ship stations usually use code values 90–99. Consequently, you should be familiar with the geographical area you are assigned to and the code each country uses.

1-11. The present weather (ww) is reported as a two-digit code figure. This code figure represents the weather occurring at the time of observation except under certain circumstances when it may represent the weather during the hour preceding the time of observation. The word description with each code figure in foldout 2 explains these instances. Foldout 2 also shows the weather type for each code figure and the appropriate plotting symbol. Some important points to remember about coding "ww" are as follows:

- If more than one weather code type occurs, the highest code number has priority except that code number 17 has preference over numbers 20 through 49.
- The word "HAIL" is added to the end of the message when hail accompanies a shower or thunderstorm.
- Code figures 00 through 03 are specifications that describe the general state of the sky during the hour preceding the time of observation.
- Code figure 19 is reported for a funnel cloud, tornado, or waterspout. However, should one of the latter two occur, add "TORNADO" or "WATERSPOUT," as appropriate, to the end of the report.

1-12. The past weather (W) represents the general character of weather during the past 6 hours, unless, the observation time occurs at 0300, 0900, 1500, or 2100 hours GMT. At these times, it represents the general weather character for the past 3 hours. When two or more values for "W" are appropriate, then the weather type having the highest code figure is usually reported. When code figure 3 is reported to indicate a sandstorm and the temperature is below freezing, the word "SANDSTORM" is added to the end of the message. This shows that the code figure for past weather was not blowing snow. When code figure 8 or 9 is used and hail occurred with the shower or thunderstorm, the words "PAST HAIL" are added to the end of the message. When code figure "8" is reported to indicate showers of snow, rain and snow mixed, snow pellets or ice pellets with the temperature above the freezing point, the plain language words "SNOW," "RAIN AND SNOW MIXED," "SNOW PELLETS," or "ICE PELLETS," as appropriate is added to the end of the message.

1-13. *Pressure and temperature (PPPTT).* The sea level pressure (PPP) is encoded to the nearest tenth of a millibar. For example, sea level pressure of 1029.9 mb is encoded as "299" and a pressure of 989.3 mb as "893." The temperature (TT) is encoded to the nearest whole degree Celsius and is coded directly when the temperature is 0° Celsius, or warmer.

TABLE 2
CONVERSION FROM METERS PER SECOND TO KNOTS

Mps	0	1	2	3	4	5	6	7	8	9
	Knots	Knots	Knots	Knots	Knots	Knots	Knots	Knots	Knots	Knots
0	-----	1.9	3.9	5.8	7.8	9.7	11.7	13.6	15.5	17.5
10	19.4	21.4	23.3	25.3	27.2	29.1	31.1	33.0	35.0	36.9
20	38.9	40.8	42.7	44.7	46.6	48.6	50.5	52.4	54.4	56.3
30	58.3	60.2	72.2	64.1	66.0	68.0	69.9	71.9	73.8	75.8
40	77.7	79.6	81.6	83.5	85.5	87.4	89.4	91.3	93.2	95.2
50	97.1	99.1	101.0	103.0	104.9	106.8	108.8	110.7	112.7	114.6
60	116.6	118.5	120.4	122.4	124.3	126.3	128.2	130.1	132.1	134.0
70	136.0	137.9	139.9	141.8	143.7	145.7	147.6	149.6	151.5	153.5
80	155.4	157.3	159.3	161.2	163.2	165.1	167.1	169.0	170.9	172.9
90	174.8	176.8	178.7	180.7	182.6	184.5	186.5	188.4	190.4	192.3
100	194.3	-----	-----	-----	-----	-----	-----	-----	-----	-----

When the temperature is below 0° Celsius, "50" is added to the temperature. Thus 60 would represent −10° Celsius. In the rare case of temperatures −50° Celsius or colder, "00" represents −50°, "01" −51°, and so forth. If you understand the coding instructions of the next group, the cloud code group, and its relationship to the sky cover value (N), it will help you in plotting the correct values.

1-14. *Cloud group* $(N_h C_L h C_M C_H)$. The data plotted from this group is of particular interest to the forecaster because it contains information on cloud types and height. In contrast to codes such as airways and METAR, which can easily be encoded or decoded, synoptic cloud data requires extensive code knowledge if you are to properly understand the actual cloud conditions being reported. Let's see why.

1-15. The first digit of the cloud group (N_h) represents the total amount of *all* low clouds. If low clouds are not present, this digit represents the total amount of *all middle* clouds. If neither low nor middle clouds are present, "0" is reported. Use table 1 to obtain the correct coded value. An important fact to recall is that the value reported for "N_h" may equal, but can NEVER exceed the value reported for "N."

TABLE 3
CLOUD HEIGHT CONVERSION

Symbol H = Height above Ground of the Base of the Cloud

Code Figure	Height in Feet	Height in Meters
0	0- 149	0- 49
1	150- 299	50- 99
2	300- 599	100- 199
3	600- 999	200- 299
4	1,000-1,999	300- 599
5	2,000-3,499	600- 999
6	3,500-4,999	1,000-1,499
7	5,000-6,499	1,500-1,999
8	6,500-7,999	2,000-2,499
9	8,000 or higher, or no clouds.	2,500 or higher, or no clouds.

1-16. The cloud types C_L, C_M, and C_H are reported in accordance with the international cloud classification system. Therefore, to understand the coding of these cloud types, review the discussion of international cloud types in Volume 2 of this course.

1-17. The cloud height value (h) of the cloud group often is misunderstood. The value encoded for "h" is the height of the *lowest* cloud in the sky if low or middle clouds are present. Although this coded height represents the lowest cloud in the sky, it may or may not be the height of the low cloud type reported, depending on the cloud type significance. When high clouds only are present, "h" is reported as "9." When the sky is completely obscured, a solidus (/) is reported for "h." Table 3 shows the height range for each coded value of "h."

1-18. *Dewpoint and pressure tendency* $(T_d T_d app)$. The dewpoint temperature ($T_d T_d$) is reported in the same manner as temperature (TT). Although the international symbolic form for the pressure tendency group ($j_a j_p j_p$) is different, the data coded is the same as in Region IV (app), as shown in foldout 1. Volume 2 discussed the coding of the "app" group. Remember that an additional group "99ppp" is reported when the pressure tendency equals or exceeds 9.9 millibars. In some areas the standard "app" group is not reported; a different group is reported in its place.

1-19. In the southern part of WMO Region IV, reporting stations in the Caribbean, Central America, Mexico, and the Bahamas replace the standard "app" group with a "$9P_{24}P_{24}$" group. The "9" indicator identifies this group. The "9" is followed by the pressure change for the last 24 hours, rather than the last 3 hours. This pressure change ($P_{24}P_{24}$) is reported as a coded value, as shown in table 4.

TABLE 4
AMOUNT OF 24-HOUR PRESSURE CHANGE

Symbol P24P24 - Amount of Pressure Change at the Station Level During Past 24 Hours

Code Figure	Amount of Pressure Change
00	No change; pressure same as 24 hours ago
01	Pressure has risen 0.1 mb
02	" " " 0.2 mb
03	" " " 0.3 mb
04	" " " 0.4 mb
05	" " " 0.5 mb
06	" " " 0.6 mb
07	" " " 0.7 mb
08	" " " 0.8 mb
09	" " " 0.9 mb
10	" " " 1.0 mb
11	" " " 1.1 mb
12	" " " 1.2 mb
etc.	etc.
38	" " " 3.8 mb
39	" " " 3.9 mb
40	" " " 4. mb
41	" " " 5 mb
42	" " " 6 mb
43	" " " 7 mb
44	" " " 8 mb
45	" " " 9 mb
46	" " " 10 mb
47	" " " 11 mb
48	" " " 12 mb
49	" " " 13 mb
50	Not Used
51	Pressure has fallen 0.1 mb
52	" " " 0.2 mb
53	" " " 0.3 mb
54	" " " 0.4 mb
55	" " " 0.5 mb
56	" " " 0.6 mb
57	" " " 0.7 mb
58	" " " 0.8 mb
59	" " " 0.9 mb
60	" " " 1.0 mb
61	" " " 1.1 mb
62	" " " 1.2 mb
etc.	etc.
88	" " " 3.8 mb
89	" " " 3.9 mb
90	" " " 4 mb
91	" " " 5 mb
92	" " " 6 mb
93	" " " 7 mb
94	" " " 8 mb
95	" " " 9 mb

1-20. **Supplemental Groups.** The remaining nine groups vary by regional requirements and station capabilities. They basically supplement or add to the information in the previous six mandatory groups. In most cases they are adequately covered in your local plotting procedures. We'll now take a brief look at each group.

1-21. The station pressure ($6P_OP_OP_OP_O$) is a relatively new group; it reports the station pressure to the nearest tenth of a millibar. Station pressures of 999.9 mb or less are coded direct. For example, 987.5 mb is reported "69875." When the pressure is 1000.0 mb or more, the code figure "3" is reported for the hundreds digit. For example, 1025.7 mb is coded "63257." The next group of the synoptic code (precipitation) has a few regional variations. These variations occur primarily because of a different unit of measure and different requirements for reporting precipitation.

1-22. The precipitation group ($7RRR_tS$) or ($7RRD_LD_M$) is used in most areas of the world. The total amount of precipitation is reported for the last 6 hours (RR) in either hundredths of an inch or in millimeters. WMO Region IV reports precipitation in hundreds of inches. If the total precipitation is less than 1 inch the value is reported directly, just as the "RR" value in airways code is reported. When the precipitation equals or exceeds 1 inch, the whole number of inches is reported in plain language after the "7" group and the fractional part of an inch is reported as the "RR" value. For example, 2.37 inches of precipitation is reported as "$737R_tS$ TWO."

1-23. If "R_t" is reported, it is a coded value which indicates the time the precipitation began or ended. Table 5 shows the time represented by each code value. When precipitation *is occurring* at the time of observation, or *has ended* during the hour preceding observation, the time the precipitation *began* is reported. When precipitation is *not occurring* at observation time, and *has not occurred* in the hour preceding the observation, the time the precipitation *ended* is reported. When two or more periods of precipitation occur during the 6-hour period, the time (beginning or ending, as appropriate) of the last period of precipitation is reported.

1-24. The depth of snow (s) is reported in inches (up to 8 inches) of snow on the ground at the observation time. When "9" is reported, it indicates a trace of snow or ice is on the ground. When more than 8 inches of snow is present, "s" is still reported as "8"; however, the actual snow depth is reported in the special phenomena group which is discussed later in this section.

1-25. In Region V (Hawaii and the Pacific) the directions from which the low (D_L) and middle clouds (D_M) are moving are reported in place of the "R_tS" data that is reported in Region IV. Cloud movement is especially significant in Region V where there is a scarcity of weather reports. For other regions of the world, it is important for you to determine the data that is reported in place of "R_tS" or "D_LD_M."

1-26. The cloud layer group ($8N_sCh_sh_s$) is only reported by designated stations in Regions IV and V. When it is reported, it contains the following:

- The lowest cloud layer of any amount.
- The next highest layer that by itself covers 0.4 or more of the celestial dome.
- The next higher layer of clouds that by itself covers 0.6 or more of the celestial dome.
- Any layer of cumulonimbus clouds.

TABLE 5
TIME PRECIPITATION BEGAN OR ENDED

Code Figure	Time Began or Ended	Code Figure	Time Began or Ended
0	No precipitation.	6	5 to 6 hours ago.
1	Less than 1 hr. ago	7	6 to 12 hours ago.
2	1 to 2 hours ago.	8	More than 12 hours ago.
3	2 to 3 hours ago.		
4	3 to 4 hours ago.	9	Unknown.
5	4 to 5 hours ago.		

1-27. Following the indicator number "8" of the group, the layer amount (N_s) is reported. Table 1 shows the sky cover amount code figures for "N_s." It is reported in the same way as layer amounts for total sky cover (Nddff). If an obscuration is present, "N_s" is coded "9." The cloud type (C) is reported as one of the ten basic international cloud types, as shown in table 6. The last two digits (h_sh_s) represent the height of the layer. For heights of 5000 feet or below, the heights are coded directly in hundreds of feet. Above 5000 feet, cloud heights are coded for 1000-foot increments; "56" represents 6000 feet, "57," 7000 feet, and so on, up to 30,000 feet. Above 30,000 feet, cloud heights are reported for 5000-foot increments; "81" for 35,000 feet, "82" for 40,000 feet, etc.

1-28. Special phenomena group ($9S_pS_ps_ps_p$) is used by synoptic reporting stations to report what the name implies—*special phenomena.* You only need to know that more than one of these groups may be reported at a time. Decoding these groups requires *Federal Meteorological Handbook No. 2, Synoptic Code.* A general rule to remember about these groups is that they are used when phenomena is observed that cannot be reported in other portions of the code.

TABLE 6
BASIC CLOUD TYPE

Code Figure	Type of Cloud	
0	Cirrus	Ci
1	Cirrocumulus	CE
2	Cirrostratus	Cs
3	Altocumulus	Ac
4	Altostratus	As
5	Nimbostratus	Ns
6	Stratocumulus	Sc
7	Stratus	St
8	Cumulus	Cu
9	Cumulonimbus	Cb
/	Cloud not visible owing to darkness, fog, duststorm, sandstorm, or other analogous phenomena.	

1-29. Internationally, the next group is the "Ijjjj" group. This group is not used in the U.S. and Pacific area, however, and its coding is determined by regional agreements in other areas. Since it is not used in the U.S. or the Pacific areas, we'll proceed to examine the next group that is used in Region IV.

1-30. The 24-hour precipitation group (2jjjj or $2R_{24}R_{24}R_{24}R_{24}$) represents the total precipitation (liquid equivalent) measured in the 24 hours before ohe observation time. Amounts of less than 0.01 inch are not reported. Precipitation is coded directly in tens, units, tenths, and hundredths of inches. When precipitation occurs during the preceding 24 hours but the amount cannot be accurately determined, "2////" is reported. Again, outside Region IV this group may be coded differently.

1-31. The wave groups ($3P_wP_wH_wH_w$) ($d_wd_wP_wH_wH_w$) when reported, are reported in the same way in all regions of the world. The "3" indicator is followed by the period of the sea waves (P_wP_w). This is determined by time lapse between two successive crests as they pass a fixed point. It is reported in seconds. When the sea is calm, "00" is reported. When the period cannot be estimated because of a confused sea, "99" is reported.

1-32. The period of sea waves is followed by the height of the waves (H_wH_w). The height is coded in 1 1/2-foot increments; therefore, the actual wave height can be obtained by multiplying the code value by 1 1/2 feet. For example, code figure 01 = 1 1/2 feet; code figure 02 = 2 × 1 1/2 = 3 feet, etc. Again, "00" indicates a calm sea.

1-33. When only wind waves are being reported, the "$d_wd_wP_wH_wH_w$" group is not included in the report. This additional group ($d_wd_wP_wH_wH_w$) refers to swell waves rather than wind waves and must always be preceded by the "3" indicator group. If there are no wind waves, the swell wave report must be preceded by the group "30000."

1-34. The true direction (d_wd_w) from which the swell waves come is reported in tens of degrees. When the sea is in a confused state, the direction is reported as "99." The period (P_w) of the swell waves is reported as a code figure rather than seconds like the period of wind waves. Table 7 shows the time period that each code figure represents. The last two digits of the swell wave group (H_wH_w) are reported the same as for the wind wave group.

1-35. The extreme temperature group (4jjjj or $4T_xT_xT_nT_n$) indicator group varies from one region of the world to another. In the U.S. the maximum (T_xT_x and minimum (T_nT_n) temperature is reported in whole degrees Fahrenheit.

- At 1800 and 0000 GMT, the maximum temperature for the previous 12 hours is reported.
- At 0600 GMT, the maximum temperature for the previous 24 hours is reported.
- At 1200 GMT, the maximum temperature for the previous calendar day (midnight to midnight local standard time) is reported.

1-36. The guidelines for reporting the minimum temperatures are as follows:

- At 0600 and 1800 GMT, the minimum temperature for the previous 24 hours is reported.
- At 1200 hours, the minimum temperature for the previous 12 hours is reported.
- At 0000 GMT, the minimum temperature for the previous 18 hours is reported.

TABLE 7
PERIOD OF THE SWELL WAVES

Code Figure	Period
2	5 seconds or less
3	6 or 7 seconds
4	8 or 9 seconds
5	10 or 11 seconds
6	12 or 13 seconds
7	14 or 15 seconds
8	16 or 17 seconds
9	18 or 19 seconds
0	20 or 21 seconds
1	Over 21 seconds
/	Calm, or period not determined

1-37. Within Region IV, the "4" indicator group is the last coded group that is reported. However, there are plain language remarks. Regardless of the number of groups or remarks in a synoptic code report, the last element is the message separation signal (θ). In other WMO regions, two more groups may be added to the report.

1-38. The 5jjjj group is included in some overseas areas. Decoding of this group requires you to research the appropriate publications. The "$6a_3hhh$" group is used only by high altitude stations outside Region IV. Basically, the "6" indicator group reports the height of an agreed standard isobaric surface. A code value for "a_3" of 0 = 1000 mb, 1 = 850 mb, and 2 = the 700-mb surface. The altitude of the isobaric surface is reported in meters (hundreds, tens, and units). The next code, ship synoptic code, requires much closer scrutiny because of the way the groups vary with each report that is transmitted.

1-39. **Ship Synoptic Code.** The ship synoptic code differs from the land synoptic code only because of different requirements for taking and reporting weather observations from a ship. The ship synoptic code repeats many of the basic groups covered by the land code; therefore, you need only to study the groups peculiar to the ship synoptic code. Turn to foldout 3 and follow along the code as we discuss it in the text.

1-40. *Location and time ($99L_aL_aL_a$ $Q_cL_oL_oL_oL_o$ $YYGGi_w$).* Following the identifier "SHIP," or the actual name of the ship, is the "99" indicator for ship synoptic code and the latitude ($L_aL_aL_a$). The latitude is reported in tenths of a degree and is used with the next group to specify the ship's position. The first digit (Q_c) of the longitude group identifies the quarter of the globe where the ship is located. The quarters are divided as follows:

	Latitude	*Longitude*
1	North	East
3	South	East
5	South	West
7	North	West

The quarter of the blobe digit is followed by the longitude ($L_oL_oL_oL_o$) which is also coded to the nearest tenth of a degree.

1-41. The next group identifies the day of the month (YY), time of the observation (GG), and wind indicator (i_w). If you use ship synoptic, study this group closely because it alerts the plotter to important conditions. For instance, if either "0" or "1" is reported for "i_w," the winds are in meters per second. The time (GG) is used to determine whether or not it is an off-time ship report, which is a common occurrence. If 30 is added to the time, a *($D_S v_S app$)*. group is not in the report, and, if 60 is added, the "Dsvsapp" and the "NhCLhCMCH" groups are omitted from the report. A typical coded report for these first three groups is: SHIP 99181 71483 13123 . . . .This partial report tells you the ship is located at 18.1° north and 148.3° west. It is the 13th day of the month, the report is for 1200 GMT, and the last digit (3) denotes that the windspeeds are in knots. The next four groups are identical to the land synoptic code.

1-42. *Ship movement and pressure tendency ($D_S v_S app$).* This is the last mandatory group of the ship synoptic code. As stated earlier, it should be absent from the report only when 30 or 60 is added to the time. The "D_S" is the ship's course and the v_S is for the ship's average speed, both for the preceding 3 hours. Table 8 shows the directions the code digits reported for "D_S" represent. When you suspect that the ship's position is wrong, you can use the next digit (v_S) to determine the rate the ship has moved from one position to another. Table 9 shows the speed represented by each coded value. This value is also determined over the preceding 3 hours. The pressure tendency data is the same as land synoptic code data.

1-43. *Temperature of the sea and dewpoint ($0T_ST_ST_dT_d$ $1T_WT_WT_Wt_T$).* The "T_ST_S" digits represent the difference between the air temperature (TT) and the sea temperature in half-degrees Celsius. When the sea temperature is warmer than the air temperature, 50 is added to "T_ST_S." For example, when "T_ST_S" is "58," it indicates the sea temperature is 8 half-degrees or 4° Celsius warmer than the air temperature. The last two digits (T_dT_d) of the "0" indicator group are the dewpoint temperature.

TABLE 8
SHIP'S COURSE (D_S)

Code Figure	Direction	Code Figure	Direction
0	Stationary.	5	Southwest.
1	Northeast.	6	West.
2	East.	7	Northwest.
3	Southeast.	8	North.
4	South.	9	Unknown.

	Latitude	Longitude
1	North	East
3	South	East
5	South	West
7	North	West

TABLE 9
SHIP'S AVERAGE SPEED (V_S)

Code Figure	Nautical Miles Per Hour	Kilometers Per Hour
0	0 nm/hr	0 km/hr
1	6-10 nm/hr	1-10 km/hr
2	6-10 nm/hr	11-19 km/hr
3	11-15 nm/hr	20-28 km/hr
4	16-20 nm/hr	29-37 km/hr
5	21-25 nm/hr	38-47 km/hr
6	26-30 nm/hr	48-56 km/hr
7	31-35 nm/hr	57-65 km/hr
8	36-40 nm/hr	66-75 km/hr
9	Over 40 nm/hr	Over 75 km/hr

1-44. The "1" indicator group is a more precise measurement of the sea temperature and enables you to determine the free air temperature to a tenth of a degree. "$T_WT_WT_W$" represents the sea surface temperature in *tenths* of a degree Celsius. When the sea surface temperature is below 0° Celsius, 500 is added to the absolute value of the sea surface temperature. For example, −31° C. is −31 tenths and would be encoded as 531. The last digit (t_T) is the tenth of a degree value for the free air temperature (TT). Therefore, when a "1" indicator group is included, the value for "TT" is *not rounded off.* Consequently you must add "t_T" to the temperature.

1-45. *Ice data* ($2I_SE_SE_SR_S$). This group provides information on the amount of ice accumulation on the ship. Table 10 shows the code figures (I_S) that indicate what is causing ice to form on the ship. Knowing what causes the icing, especially icing caused by precipitation, helps the forecaster as well as pilots in the area. The next two digits (E_SE_S) pertain to the ice thickness in centimeters. The last digit (R_S) pertains to the tendency of the icing (whether it is increasing or melting). The "c_2KD_ire" group at the end of the ship synoptic report is another ice group. The "c_2" gives you a description of the kind of ice observed on the sea surface at the shore line. The "K" describes the effect that the ice has on navigation. The "D_i" gives the bearing of the ice edge from the ship, and the "r" gives the distance. The "e" gives the orientation of the ice edge to the point of observation. All these values are coded. FMH No. 2 contains the conversion tables. Occasionally, a need arises for plain language remarks in a ship synoptic report. One such example is the plain language coding of ice phenomena that cannot be coded in the basic groups. The next code, airways code, is the primary code plotted within the U.S.

1-46. **Airways Code.** After completing Volume 2, it should not be necessary to repeat the coding instructions here. However, you should realize the uses and great importance

TABLE 10
ICE ACCRETION ON THE SHIP (I_s)

Code Fig-ure	Specifications
1	Icing from ocean spray.
2	Icing from fog.
3	Icing from spray and fog.
4	Icing from rain.
5	Icing from spray and rain.

this code has in daily weather station operations within the U.S. Turn to foldout 4 and you'll note that the airways code provides four different possible plotting models. By using different plotting models of airways code reports, you can satisfy most surface chart needs. This is not always the case with synoptic code. One of the chief advantages of using the airways code is that remarks of an operational and meterological nature are included and the reports are received hourly; whereas, synoptic reports are received only once every 3 hours.

1-47. Generally, each weather station plots at least one local area surface chart (LASC) a day using airways code. If only one chart is plotted daily it is usually a complete 3- or 6-hourly plotting model, as shown in foldout 4. A plotting model, such as shown in foldout 4, for a 3- or 6-hourly plot normally presents no problem; unlike chart scales that land synoptic data is plotted on, local area surface charts are designed so that a complete airways plotting model can be plotted for each station without affecting nearby stations.

1-48. Operation at a weather detachment varies greatly from season to season. As weather systems advance toward the station, the forecaster must alert base operations of impending weather conditions. This may require a special local area work chart (LAWC) for tracking a fast-moving front, a depiction of ceiling layers in the area, a severe weather outlook, or an analysis of precipitation amounts and rate of movement. In any case, the added plotting requirement is more effective if you know the plotting procedures as shown in foldout 4. First the forecaster receives the chart in less time, thereby increasing its value; and, secondly, you have more time to spend on other duties that usually increase when weather conditions are deteriorating. At overseas stations, METAR code provides much the same weather coverage that airways code provides in the U.S.

1-49. **METAR Code.** If you are an observer at an overseas location, you can expect to become very familiar with METAR code. At present, the weather observer graduates from Course 3ABR-25231 receive only limited instruction in METAR code. METAR code does not alter the principles of surface weather observations, which are basically the same throughout the world; rather, it requires different coding instructions. Therefore, if you are familiar with the METAR code content, you should be able to encode or decode METAR reports. Turn to foldout 5 and follow the METAR plotting guide as we discuss each coded group.

1-50. The time group, "GGgg," is always placed in the heading of a collective, indicating the times of the observations in the collective. The time group is usually the standard time of the observation (1500Z, 1900Z, etc.). Reports which differ from the collection time by more than 10 minutes must contain a separate time group. The next group, "CCCC" in a collective, is usually the station identifier.

1-51. The mean direction and speed of the wind for the 10-minute period immediately preceding the observation are reported for "dddff." The direction of the wind is reported in tens of degrees; consquently, the third figure of "ddd" is always zero. If the maximum windspeed during the 10-minute period exceeds the reported windspeed by more than 5 knots, the maximum speed is reported for "$/f_mf_m$" immediately after "dddff." Otherwise, the "$/f_mf_m$" element is not reported. Mean windspeeds and maximum windspeeds in excess of 99 knots are reported in three digits; for example, "290103/126" for a mean windspeed of 103 knots and a maximum windspeed of 126 knots. A calm wind is reported "00000," and a variable wind direction is reported "VRB." To be coded "VRB," the wind direction must fluctuate 60° or more and the windspeed must be greater than 6 knots during the period of observation.

1-52. The visibility, "VVVV," is reported in meters—to the nearest 100 meters up to 5000 meters, and to the nearest 1000 meters between 5000 and 9000 meters. Since 5000 meters is the same as 5 kilometers, you may think of visibility in terms of kilometers for reported values of "5000" and above. When the visibility is more than 9000 meters (approximately 6 statute miles), report "9999."

1-53. Runway visual range is reported in the form "$RV_RV_RV_RV_R$". Runway visual range is reported when the *prevailing visibility* is 1 mile or less or when the *runway visual range* is 6000 feet (1830 meters) or less. Although runway visual range is determined in hundreds of feet, it is reported in meters. Values below 300 meters and above 1830 meters are not reportable values and are coded M0300 and P1830 (M means minus and P means plus). The reportable runway visual range values are converted to meters as follows:

RVR in Hundreds of Feet	*Reported in Meters*
10–	M0300
10	0300
12	0360
14	0420
16	0490
18	0550
20	0610
22	0670
24	0730
26	0790
28	0850
30	0910
32	0970
34	1030
36	1100
38	1160
40	1220
45	1370
50	1520
55	1670
60	1830
60+	P1830

1-54. Weather phenomena (w'w') occurring at the time of observation are encoded similar to present weather in synoptic code. The values are derived from tables, as they are in synoptic code. In the METAR code, however, the numerical value from the table is followed by an abbreviation which further describes the phenomenon. This abbreviation is two or four letters so that the w'w' is either four or six characters. For example, "95" is used to report a thunderstorm in the synoptic code, but in METAR code the abbreviation "TS" is added so that the group becomes "95TS." Similarly, a severe thunderstorm is reported "97XXTS" in METAR code.

1-55. The letter abbreviations make it easy for you to decode the present weather element of the METAR code, although they are intended primarily to make decoding easier for nonweather personnel. There is nothing mysterious about the letter combinations used as abbreviations in the w'w' group. Some of the basic abbreviations are as follows:

Code	*Weather Element*
FG	Fog
FU	Smoke
DZ	Drizzle
RA	Rain
SN	Snow
GR	Hail
TS	Thunderstorm

1-56. These abbreviations are amplified by preceding them with "FZ" for freezing and "XX" for heavy or by following them with "SH" for showers. Therefore freezing drizzle is "FZDZ," heavy rain is "XXRA," rain and snow occurring together are "RASN," and rain showers or snow showers are "RASH" or "SNSH." The numerical coded figure, of course, is still the basic designator for weather phenomena and clarifies the meaning of the group further. The abbreviation "RASN" denotes rain and snow occurring together, but the numerical value indicates the character of the precipitation; "68RASN" means continuous rain and snow, whereas "83RASN" means showers of rain and snow. Note that in the latter case the "SH" for showers is not used in order to limit the group to six characters. The "83" establishes the showery character of the precipitation. Foldout 2 contains the familiar present-weather chart, showing the coded values for the present weather.

1-57. The cloud group "$N_sCCh_sh_sh_s$" is repeated to report a number of layers. For each individual layer, amounts (N_s) are entered to the nearest eighth. When two or more types of clouds occur with bases at the same level, the amount entered will refer to the total amount of clouds of all types at that level except when one of the clouds is cumulonimbus and it does not represent the greater amount.

1-58. The "CC" element of the "$N_sCCh_sh_sh_s$" group represents the type of obscuring phenomena or cloud. When two or more types of clouds occur with bases at the same level, the type that represents the greatest amount is coded. In the case of equal amounts, the type which is considered more significant is coded. When cumulonimbus clouds are observed at the same level as other cloud types, and are not reported because they do not represent the greatest amount, each type is coded in separate cloud groups; e.g., for 3/8 clouds observed at 3000 feet consisting of 1/8 CB and 2/8 CU, 1CB030 2CU030 is coded. The 10 reportable cloud types and the 10 reportable obscuring phenomena types are:

Code	*Cloud Type*	*Code*	*Obscuring Phenomena*
CI	Cirrus	DZ	Drizzle
CC	Cirrocumulus	GR	Hail
CS	Cirrostratus	RA	Rain
AC	Altocumulus	PE	Ice Pellets
AS	Altostratus	SN	Snow
NS	Nimbostratus	SN	Blowing Snow
SC	Stratocumulus	FG	Fog
ST	Stratus	HZ	Haze
CU	Cumulus	SA	Sand
CB	Cumulonimbus	FU	Smoke

given by a three-digit code: Following are some code figures and corresponding height values from the code table:

Code Figure	*Feet*	*Meters*
000	<100	<30
001	100	30
002	200	60
--	--	--
020	2,000	600
--	--	--
048	4,800	1,440
049	4,900	1,470
050	5,000	1,500

Code Figure	*Feet*	*Meters*
055	5,500	1,650
060	6,000	1,800
065	6,500	1,950
--	--	--
095	9,500	2,850
100	10,000	3,000
--	--	--
110	11,000	3,300
120	12,000	3,600
130	13,000	3,900
--	--	--
300	30,000	9,000
350	35,000	10,500
400	40,000	12,000

When the sky is totally obscured, "N_s," is coded "9," and the cloud group is coded "$9//h_sh_sh_s$," where "//" is the two letter phenomena causing the obscuration and "$h_sh_sh_s$" is the vertical visibility.

1-60. A partial obscuration is encoded as a cloud group. The amount of sky hidden by the partial obscuration is entered first, followed by the two letter phenomena causing the obstruction, and /// in place of "$h_sh_sh_s$." Some typical examples are:

- 2FG///
- 4HZ///
- 2FU///

1-61. The temperature and dewpoint group ($T'T'/T_dT_d$) follows the cloud group ($N_sCCh_sh_s$) in the symbolic form. The air temperature and dewpoint temperature are reported in whole degrees Celsius. Values less than 10° are preceded with a zero in order that values reported are always in two digits. For example, a temperature of 9° C. is reported "09." Negative temperature values are preceded with the letter "M" (minus) so that a temperature of −9° C. is reported "M09."

1-62. The altimeter setting is reported in the group "$P_HP_HP_HP_H$." Air Weather Service stations report altimeter settings in inches of mercury and add the contraction "INS," i.e., "2989INS."

1-63. An additional group reported is the group "CIG(D)hhh." This group is reported when a ceiling, variable ceiling, or surface based total obscuration exists. *Ceiling* is the height of the lowest layer of clouds or obscuring phenomena that covers 5/8 or more of the sky at and below that level. This group clarifies the sky condition by specifying the ceiling (CIG), the ceiling height classification designator (M, R, A, E, etc.) (D), when the ceiling is less than 3000 feet, and the ceiling height. The ceiling height includes vertical visibility into a totally obscured sky. When a layer(s) of clouds is reported, the amount of which is 5/8 or more, but the layer(s) is not opaque, the remark "CIGNO" is entered as the first remark in the observation. If a variable condition exists and the variability affects the reporting of a ceiling below 3000 feet, the condition existing at observation time will be coded. Some examples of variable sky cover are:

Observed	*Sky Condition*
2/8 Sc, Varying to 3/8	2ST010 2SC025
3/8 Sc, Varying to 2/8	2ST010 3SC025
2/8 St, Varying to 1/8	2ST010 3SC025 1AC080

Remark

CIGNO OCNL CIGM025
CIGM025 OCNL CIGNO
CIGE025 OCNL CIG080

1-64. As the symbolic form indicates, the last element of a METAR report is reserved for remarks. Volume 2 describes the method for reporting remarks. The emphasis placed on the importance of remarks in Volume 2, in relation to airways reports, also applies to METAR reports. Anything that amplifies and clarifies the observation or makes it more representative is appended to the report as a remark.

1-65. The term "SPECI" designates an aviation selected special report. This code provides for the dissemination of special observations in the same basic code form as METAR reports. There are only two significant differences. For one thing, the time reported with a SPECI report is the actual time of the special observation. Second, the temperature/dewpoint and altimeter setting groups are *not* included in SPECI reports. All other elements of the code are identical with the METAR code form and are governed by the same coding instructions.

1-66. As with airways code in the United States, your station has a current plotting model for METAR code. Once you're familiar with the standard plotting models at your station, it should be easy for you to adapt to plotting models used in locally produced charts.

1-67. As with airways code in the United States, your station has a current plotting model for METAR code. Once you're familiar with the standard plotting models at your station, it should be easy for you to adapt to plotting models used in locally produced charts.

1-68. **Local Area Charts.** Each detachment is responsible for establishing a local analysis program (LAP). This program provides the detachment with the locally prepared charts to supplement the centrally produced charts (facsimile). These locally produced charts are usually referred to as the local area surface chart (LASC) or the local area work chart (LAWC). The main difference between these charts is that the LASC is used for more complete analysis; hence, it requires more plotting elements. Most detachments require at least one LASC per day and usually display it in a prominent position in the briefing area.

1-69. The LAWC provides the forecaster with information on operationally significant weather existing or expected within the local area. The forecaster may request an LAWC to be plotted frequently during periods of inclement weather. If he should, your station has instructions on what to plot on each, including the weather type that may be plotted on LAWCs or LASCs. Although LAWCs can be developed from upper air data, our discussion of these locally produced charts centers primarily on the surface chart variety. In understanding the role your detachment has in the development of locally produced charts, you should examine the various sources of data available for plotting.

1-70. *Sources of data.* Since airways code is most frequently plotted on local weather charts, an impression is created that these charts are limited to this source of data. This is not the case! Granted, the analyses required for a standard LASC requires that a weather code such as airways be plotted. However, any of the basic surface weather codes may be used for plotting locally prepared charts including:

- Airways.
- METAR.
- Ship Synoptic.
- Land synoptic (backup).

1-71. When special analysis requirements exist, the forecaster may ask you to plot weather data that is of an "unscheduled" variety. These codes are:

- Radar reports.
- Pilot reports.
- Severe weather advisories.
- Rawinsonde and dropsonde data (1000-mb or 850-mb levels).
- Weather reconnaissance reports.
- COMBAR and AIREP reports.

1-72. As shown above, almost any type of data may be plotted on a local weather chart. For instance, RECCO data may be very useful if you are located at a coastal region where a tropical depression or hurricane is approaching and the forecaster needs to monitor the storm's every movement. In this case, you may be somewhat "rusty" in plotting these reports. Therefore, there will probably be a plotting guide located near the working area. Because many of these codes are discussed in other sections of this volume, you should review the codes that are usually restricted to plotting on LASCs or LAWCs. The first of these, pilot reports, provides the forecaster with information on actual sighting of weather phenomena and is especially helpful in the identification of severe weather areas, turbulence, icing, and other phenomena hazardous to flight operations.

1-73. *Plotting pilot reports.* At the weather detachment that supports flight operations on a large scale, pilot report information has an important part in station operations. The forecaster uses pilot reports to brief pilots on weather phenomena that they may experience over the same flight path. The forecaster also uses this source of data to confirm his predictions of weather movement and development. There are several methods for making this data more meaningful to the forecaster and other users. They should be filed near the pilot-to-forecaster (PSFV) communications unit for ready accessibility and plotted on a special pilot report chart by using an abbreviated form of weather symbols or a numbering system. These methods of using pilot report data are satisfactory in most uses; however, on occasion, a need arises to display this information symbolically on a weather chart.

1-74. Your station has established standard policies for plotting pilot reports, based on AWS Manual 105—22, *Local Weather Analysis Program.* Some general plotting rules that are usually followed at most stations are:

a. When duplicate reports are received, plot the latest report.

b. Always enter the time of observation.

c. Illustrate the location of the phenomena.

d. Enter the aircraft type with PIREPs that contain turbulence, icing, electrical discharge, and contrail remarks.

e. Plot recognizable meteorological symbols for the weather phenomena.

1-75. Figure 2 shows an example of two plotted pilot reports. One example shows a report of phenomena over a specific area, whereas the other shows a report over one location. In both cases the forecaster is able to interpret this data more easily than if he had to read the report directly from the teletype

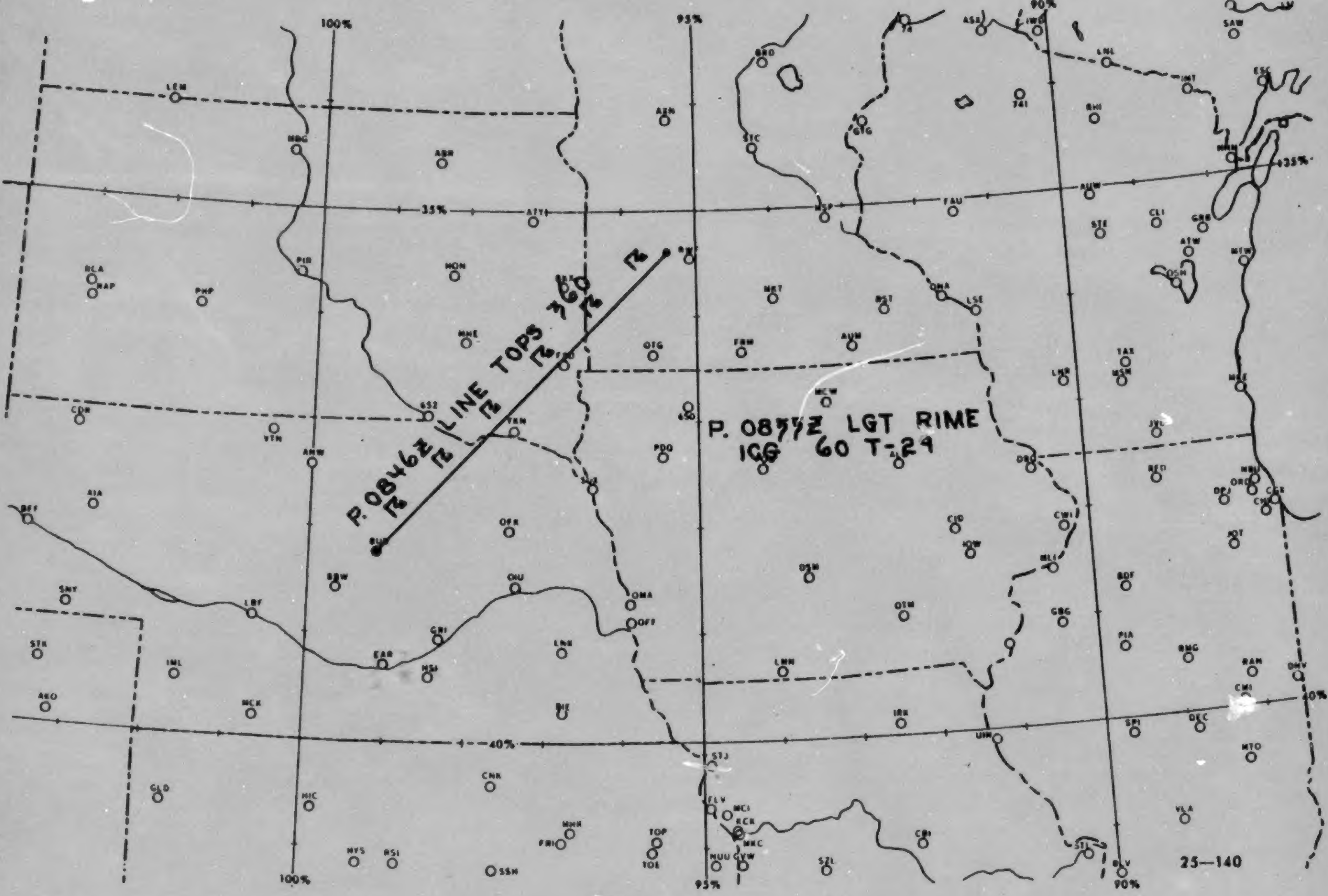
P. 0846Z LINE TOPS 360
P. 0857Z LGT RIME ICG 60 T-29
100%
95%
90%
35%
40%
25—140

Figure 2. Plotted pilot reports.

3

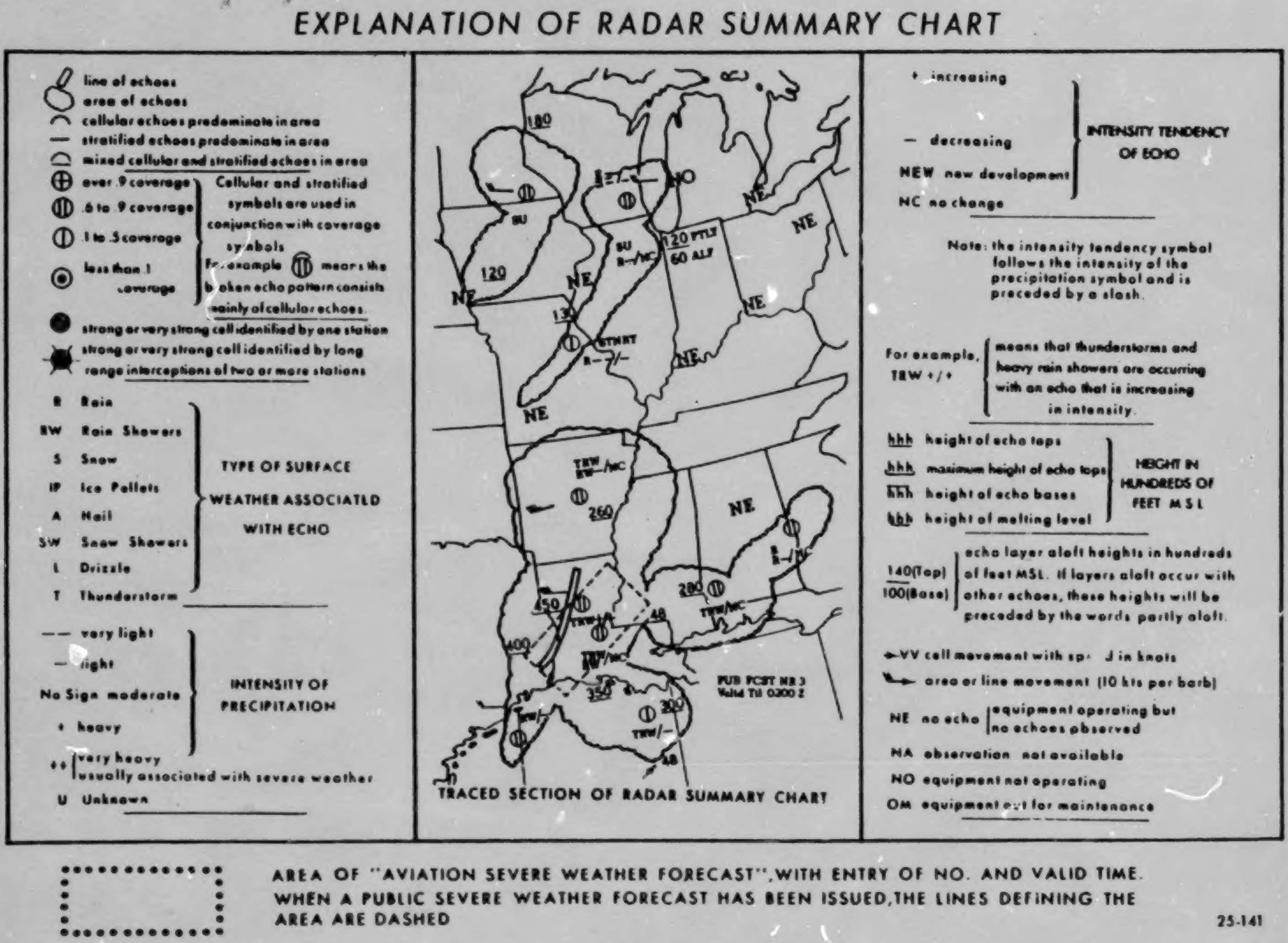
EXPLANATION OF RADAR SUMMARY CHART
line of echoes
area of echoes
cellular echoes predominate in area
stratified echoes predominate in area
mixed cellular and stratified echoes in area
over .9 coverage
.6 to .9 coverage
.1 to .5 coverage
less than .1 coverage
Cellular and stratified symbols are used in conjunction with coverage symbols
For example ⓘ means the broken echo pattern consists mainly of cellular echoes.
strong or very strong cell identified by one station
strong or very strong cell identified by long range interceptions of two or more stations
R Rain
RW Rain Showers
S Snow
IP Ice Pellets
A Hail
SW Snow Showers
L Drizzle
T Thunderstorm
TYPE OF SURFACE WEATHER ASSOCIATED WITH ECHO
-- very light
- light
No Sign moderate
+ heavy
++ very heavy usually associated with severe weather
U Unknown
INTENSITY OF PRECIPITATION
TRACED SECTION OF RADAR SUMMARY CHART
180
120
SU
NE
120 PTLY 60 ALF
SU R-/NC
NO
130
STNRT R-/-
TRW RW-/NC
260
450
400
48
280
TRW/NC
350
300
TRW/-
PUB FCST NR 3 Valid Til 0200 Z
+ increasing
- decreasing
NEW new development
NC no change
INTENSITY TENDENCY OF ECHO
Note: the intensity tendency symbol follows the intensity of the precipitation symbol and is preceded by a slash.
For example, TRW +/+ means that thunderstorms and heavy rain showers are occurring with an echo that is increasing in intensity.
hhh height of echo tops
hhh maximum height of echo tops
hhh height of echo bases
hhh height of melting level
HEIGHT IN HUNDREDS OF FEET MSL
140(Top) 100(Base) echo layer aloft heights in hundreds of feet MSL. If layers aloft occur with other echoes, these heights will be preceded by the words partly aloft.
VV cell movement with speed in knots
area or line movement (10 kts per barb)
NE no echo equipment operating but no echoes observed
NA observation not available
NO equipment not operating
OM equipment out for maintenance
AREA OF "AVIATION SEVERE WEATHER FORECAST", WITH ENTRY OF NO. AND VALID TIME. WHEN A PUBLIC SEVERE WEATHER FORECAST HAS BEEN ISSUED, THE LINES DEFINING THE AREA ARE DASHED
25-141

Figure 3. Plotted radar reports.

report. The forecaster can use this data along with radar reports and surface weather observations to obtain greater insight into some of the atmospheric processes that continually challenge and confront him. Often a pilot is in a position to report weather phenomena, such as newly formed lines of convective clouds, that have not been identified on radarscopes. This information provides "added" information about severe weather development.

1-76. *Plotting radar reports.* At times, the sole indication of severe weather in the area is revealed by radar observations. The network of radar reporting stations that covers the entire United States is adequate to detect areas of severe weather. Just as the military weather warning center evaluates all radar reports transmitted by the various reporting stations, each weather detachment is concerned with evaluating reports of echoes. The forecaster can do this by making visual inspections of incoming radar reports. In many cases, however, this technique does not provide the forecaster with the information essential for a reliable forecast of severe weather. He must see the radar echoes displayed on a weather chart with respect to their actual location. Then he can better visualize the atmospheric changes taking place when he compares these observations with other weather reports and facsimile charts. One of your jobs is to plot these radar reports so that the forecaster can obtain this better picture.

1-77. One widely used way to display radar reports on maps is to outline the dimensions of the echo area and enter the significant parts of the report within the outlined area. Figure 3 shows the guidelines for plotting the *various types* of radar reports. These plotted reports should include the *movement, size,* and *intensity.* Also, sometimes, a color code is used to indicate different reporting times, which enhances the picture for the forecaster. Closely related to the plotting of radar reports is the plotting of severe weather advisory data on locally produced charts.

1-78. *Plotting severe weather advisories.* Severe weather advisories, in many cases, are the most important weather messages received at a detachment; especially during the spring and summer months. During this period the forecaster closely monitors weather areas, such as frontal zones, that could be hazardous to flight operations. At times such as these, the forecaster may request that an LAWC be plotted with the latest severe weather advisories outlined in colored pencil. These plotted reports of expected severe weather, along with surface weather reports, provide the forecaster with an excellent picture of severe weather development within his area of responsibility.

1-79. Military and civilian weather warning centers disseminate warnings by several methods. Regardless of the teletype message format in which they are received, it is your job to plot the warning on LAWCs. Some guidelines that are helpful in the plotting of severe weather advisories are:

- Locate and plot the area outline with measuring devices such as rulers and protractors.
- Know the chart scale and the number of miles that 1 inch represents.
- One degree of latitude equals approximately 60 nautical miles.
- Enter the valid times of the report within the area outline and the advisory number.
- Enter the type and severity of phenomena expected within the area outline.

1-80. Other types of data that may be plotted on locally produced charts, such as upper air data, are plotted by using the same general format on all types of charts. Before you continue with Section 2, Upper Air Charts, refer to the chapter review exercises in your workbook and answer the items for this section.

2. Upper Air Charts

2-1. People from all walks of life fear mother nature's most damaging creations—tornadoes and hurricanes. Their violence and unpredictability have prompted many new tracking and reporting systems in recent years. In the midwest, where most of our farm products are produced, the farmer must contend with the ever-changing face of mother nature. His crops depend on rainfall, but they are jeopardized by high wind and hail. In Florida the citrus grower may lose his entire crop through an unexpected early frost. As a meteorologist, the forecaster uses all sources of data to provide accurate forecasts and briefings for using agencies. He is responsible for providing pilots with comprehensive briefings of flight conditions. In many cases, his forecasts decide the success of military operations. He can rely on the surface analysis for only part of the story. He knows that surface weather characteristics are a direct result of changes throughout the atmosphere. His forecast for local thunderstorm activity is based primarily on variances in our atmosphere.

2-2. At most AWS detachments throughout the world, the forecaster receives his upper level charts over facsimile circuits. In most cases, a sufficient number of upper level charts is received. However, when the facsimile machine is inoperative or during periods of special flight operations, you may be required to plot selected upper air charts. Section 1 discussed the codes of surface data normally received at weather stations. At forecast centrals, the plotting of upper air charts is a routine observer function. Upper air data furnishes us information about the state of the atmosphere beyond the reach of our surface instruments. This information becomes meaningful to you only when you understand the codes used to record the data. Knowing the codes permits you to plot constant pressure, winds aloft, Skew-T, and continuity charts.

2-3. In this section we will discuss the radiosonde and upper wind codes. After a brief review of these codes, we will discuss plotting data on the upper level charts. The plotting models and the general instructions that are used are found in AWSM 105–22, *Local Weather Analysis Program*.

2-4. **Radiosonde Code.** The manual for radiosonde code and the AWSM 105–24, *Meteorological Codes*, discuss the code format that is used and the data included in the radiosonde code. The complete code is divided into four individual parts (A, B, C, and D). Parts A and C are for worldwide distribution. Parts B and D are normally intended for distribution in continental or regional areas. The United States has elected to collect and distribute Parts A and B in a single message, referred to as the *first transmission*. The code name "TEMP" has been assigned to the upper air observation from a land station. The code names are for precise reference purposes only and are not transmitted.

2-5. Parts A and B, normally completed soon after termination of the sounding, are transmitted first to expedite the distribution of data. This makes data available while the remainder of the sounding is being evaluated and coded. Several hours later the remaining parts—C and D, are distributed as a *second transmission*. The first transmission provides sounding data up to and including 100 millibars (mb). Each of the coded parts contains a specific type of level.

2-6. *Types of levels*. It is customary to call certain standard isobaric surfaces "mandatory" levels. These designated mandatory levels chosen by a World Meteorological Organization (WMO) agreement must appear in every report if the sounding reaches these mandatory levels. Parts A and C are composed of mandatory levels. Part A contains only the mandatory levels at 100 mb and below, and Part C the mandatory levels above 100 mb. Parts B and D are the levels containing the significant changes in either temperature or humidity occurring between the mandatory levels. Hence the term "significant levels." Part B includes significant levels up to 100 mb and Part D the levels above 100 mb. The following format shows the radiosonde code that applies to WMO Regions IV (North and Central America) and V (Southwest Pacific).

PART A:

TT $YYGGI_d$ IIiii	(Identification—Section 1)
$99P_oP_oP_o$ $T_oT_oT_{ao}D_oD_o$ $d_od_of_of_of_o$	(Surface Data)
00hhh TTT_aDD ddfff	(Standard Isobaric Surfaces—Section 2)
85hhh TTT DD ddfff	
70hhh TTT_aDD ddfff	
50hhh TTT_aDD ddfff	
40hhh TTT_aDD ddfff	
30hhh TTT_aDD ddfff	
20hhh TTT_aDD ddfff	
15hhh TTT_aDD ddfff	
10hhh TTT_aDD ddfff	
$38P_tP_tP_t$ $T_tT_tT_{at}D_tD_t$ $d_td_tf_tf_tf_t$	(Tropopause Data—Section 3)
77 or $66P_mP_mP_m$ $d_md_mf_mf_mf_m$	(Maximum Wind Data—Section 4)

PART B:

VV YYGG/ IIiii	(Identification—Section 1)
$00P_oP_o$ $T_oT_oT_{ao}D_oD_o$	(Surface Data)
11PPP TTT_aDD	(Significant Levels—Section 5)
22PPP TTT_aDD	
33PPP TTT_aDD . . . . . etc.	
31313 25hhh TTT_aDD ddff	(Data for 250-mb Surface—Section 7)
51515 $101A_{df}A_{df}$	(Regional Codes—Additional Data—Section 9)

PART C:

WW $YYGGI_d$ IIiii	(Identification—Section 1)

70hhh TTT_aDD ddfff
50hhh TTT_aDD ddfff
30hhh TTT_aDD ddfff
20hhh TTT_aDD ddfff
10hhh TTT_aDD ddfff

07hhh TTT_aDD ddfff
05hhh TTT_aDD ddfff
03hhh TTT_aDD ddfff
02hhh TTT_aDD ddfff
01hhh TTT_aDD ddfff

(Standard Isobaric Surfaces—Section 2)

$88P_tP_tP_t$ $T_tT_tT_{at}D_tD_t$ $d_td_tf_tf_tf_t$ (Tropopause Data—Section 3)
77 or $66P_mP_mP_m$ $d_md_mf_mf_mf_m$ (Maximum Wind Data—Section 4)

PART D:
YY YYGG/ IIiii (Identification—Section 1)
11PPP TTT_aDD
22PPP TTT_aDD
33PPP TTT_aDD
44PPP TTT_aDD . . . . . etc.

(Significant Levels—Section 5)

51515 $101A_{df}A_{df}$ (Regional Codes—Additional Data—Section 9)

Times of observation are also prescribed by the WMO because of the international usage of the code.

2-7. *Observation times.* The WMO standard hours of observation are 0000 and 1200 GMT. If only one observation per day is taken, it is taken at one of the standard times according to instructions issued to the station. When more than two observations are taken per day, either 0600 and/or 1800 GMT is prescribed. The following paragraphs discuss the coding of the observation time in the report along with the coding of the other data included in the individual parts.

2-8. **Parts A (Radiosonde Code).** When referring to the code format, you notice that Part A is subdivided into sections. Each section is described as Identification, Surface Data, Standard Isobaric Surfaces, Tropopause Data, and Maximum Wind Data. Within each section are several groups. For your convenience, the discussion of each part of the code follows this same outline.

2-9. The code format also shows that Parts A and C have a noticeable similarity. Another similarity exists between Parts B and D. To avoid repetition of discussion, Parts A and B are outlined in detail, while only the unique features of Parts C and D enter our study.

2-10. *Identification code.* The message identifier for Part A appears as the first group. This two-letter group, TT, provides quick identification of Part A regardless of whether the observation comes from a land or ship station. The next group, YYGG, reports a coded date and time for the observation. The day of the month (according to GMT) and the unit of windspeed used in the report are coded together in the two-digit YY symbol. Code figures 01 to 31 indicate the day of the month. When 50 is added to the day of the month code figure, it means the *knot* is the unit of measurement for windspeed in the entire report. When the meter per second unit is used, the day of month code figure appears unaltered. All United States stations report winds in knots; therefore, code figures 51 through 81 indicate the date in the U.S.

2-11. The time of observation, GG, is coded in whole hours GMT. If you let H refer to the standard time of observation, soundings may be taken anytime between H minus 45 to H, while H minus 30 is the preferred release time. Any observation taken within the 45-minute time range has a standard time reported for GG. A balloon release outside that time range has the *nearest* whole hour reported for GG (which may not be a standard observation time).

2-12. Appended to the date/time group is an indicator, I_d, signifying available wind data. This code figure indicates the highest mandatory level at which wind data is reported even though a lower surface may have a missing wind. Suppose wind data is available in Part A for all levels including 100 mb. The I_d is coded as 1. Code figure 1 would also be reported despite a missing wind at 300 mb. If 150 mb was the last level for winds, code figure 2 is reported; 200 mb, code figure 3; 300 mb, code figure 4, etc., with each mandatory level being assigned an I_d code figure. The wind group is included for all the levels at and below the level indicated by I_d, and omitted from the levels above. Each part contains its own I_d, but since winds are not normally reported for significant levels, Parts B and D have a solidus (/) coded for I_d.

2-13. The last identification group, IIiii, expresses a geographical and station numbering system. The block number, II, designates a geographical area composed of 1000 stations. Each station is assigned a three-digit number identifier, iii. Used together, the block and station number identify one observing station in the world without duplication anywhere. As suggested by the title, the identification section is not plotted. Perhaps the least understood is the wind indicator, I_d. The task of plotting begins with the next section of the code where surface data is reported.

2-14. *Surface data.* Parts A and B both contain surface data. Two noticeable differences exist between the data. First, the indicators are different; second, only Part A surface data reports the wind. The surface data indicator for Part A is 99, rather than 00 as in Part B. Using 99 avoids possible confusion with the 00 indicator for the 1000-mb level also reported in Part A.

2-15. Part of the surface data reported is the pressure, PPP. The pressure value represents surface pressure in whole millibars at one of three possible locations. The location with first priority is the height of the instrument shelter. When the surface pressure is greater than 1000 mb, the coded value omits the digit "1." No further interpretation is necessary in decoding this pressure value before plotting it. The remaining surface data includes temperature, dewpoint depression, and wind direction and speed. Since other levels commonly contain these elements also, the details of their coding follow in later paragraphs. Surface data is always included in Part A in three separate groups. Any missing portion of the data is indicated by a solidus (/).

2-16. Other mandatory levels reported in Part A give temperature, dewpoint depression, and wind data for isobaric (constant pressure) levels. The isobaric levels vary in height. Therefore, height instead of pressure is reported for the standard isobaric levels.

2-17. *Standard isobaric levels.* Each isobaric level uses two digits of its own pressure as a level indicator. The indicator 00 denotes 1000 mb; 85 indicates 850 mb; and 70 for 700 mb. No duplicate indicators exist in any one code part. However, you may notice that both Parts A and C contain 70 indicators. There should be no confusion from this identifier, since Part A is coded only to 100 mb and Part C is coded for levels above 100 mb. The 70 indicator in Part C signifies 70 mb.

2-18. Following the indicator for each mandatory isobaric level, you find a height (hhh) for that level. These heights are to the nearest whole meter up to 500 mb, and to the nearest 10 meters at 500 mb and above. A group of "85491" indicates that the data are for the 850 mb level (85) and that the height is 1491 meters above sea level (491). The group 40714 means that 400-mb level is at 7140 meters. The coded value in three digits cannot, of course, reflect the complete height. You determine the proper prefix for each coded value from the standard heights printed on the Skew-T chart at each level or judge them from experience.

2-19. These heights tell the forecaster where each standard isobaric surface stands with respect to the last sounding and to the computed standard height. When this information is considered for each level, it provides the forecaster with indications of troughing, ridging, and warm or cold air advection.

2-20. Three separate groups contain the reported data for each mandatory level. However, if the I_d indicator shows that winds are not reported, only two groups represent each level. Every level must appear in sequence, even if the data for a level is missing. Frequently the 1000-mb level is below surface and, obviously, temperature and wind data cannot be determined; however, the report still maintains proper sequence by showing 00hhh ///// ///// for the missing data.

2-21. Similar to the surface level, the isobaric levels contain reports of temperature, dewpoint depression, and winds. Since the coding for these elements applies identically to all parts of the code, they can be discussed here as a unit.

2-22. *Temperature and dewpoint data.* It is not uncommon for a complete radiosonde report to contain a combined total of more than 60 temperature and dewpoint values. This alerts you to the importance of decoding these values accurately. An incorrectly decoded value can result in a poor analysis of the various charts on which these data are plotted.

2-23. The value of "TT" indicates the temperature in whole degrees Celsius for appropriate levels. This is also true for "T_oT_o" and "T_tT_t," which represent the temperature for the surface and the tropopause. These values are not complete unless you decode the value for "T_a," "T_{ao}," or "T_{at}." When decoded, these values give you the tenths value for the temperature and at the same time indicate whether the temperature is below or above zero. These tenths values range from "0" through "9."

2-24. To decode a temperature group (TTT_aDD) of "05718" from the radiosonde code, use table 11 to determine what the T_a value "7" indicates. Table 11 shows you that the temperature (TT) is a minus value with a tenths value of 0.6 or 0.7. In this example, the decoded temperature is −5.7° Celsius. From table 11, notice that the positive temperatures are indicated by even numbers and the negative temperatures by odd numbers. Although table 11 shows that the tenths value indicated by "7" could be either 0.6 or 0.7, it is not intended that you decide which value to use. Consider the tenths value to be the same as the coded value.

2-25. The dewpoint depression, DD, may be reported either as an actual or a coded figure. For depressions of 5° or less, the actual value in degrees and tenths is reported. The number 32 represents a 3.2° depression in Celsius degrees. A coded figure represents depressions over 5°. Additionally, the larger depressions are encoded as whole degrees only. Each DD value over 5° is coded by adding 50 so that 56 becomes a depression of 6°, 57 for 7°, 60 for 10°, and further until 99 signifies a 49° depression. There is no provision for larger depressions. Also, values 51 through 55 should never be reported.

2-26. When solid (//) are reported for temperature and dewpoint data, they are either missing or unobtainable. For example, the dewpoint depression is not reported when the temperature is below −40° Celsius because of equipment limitations and encoding instructions.

TABLE 11
TENTHS VALUES

Symbol T_a = Approximate tenths value and sign of the air temperature at the standard isobaric surfaces and significant levels.

Symbol T_{ao} = Approximate tenths value and sign of the air temperature at the surface.

Symbol T_{at} = Approximate tenths value and sign of the air temperature at the level of the tropopause.

Code Figure	Sign of Temperature*	Temperature
0	+	0.0 and 0.1
1	-	0.0 and 0.1
2	+	0.2 and 0.3
3	-	0.2 and 0.3
4	+	0.4 and 0.5
5	-	0.4 and 0.5
6	+	0.6 and 0.7
7	-	0.6 and 0.7
8	+	0.8 and 0.9
9	-	0.8 and 0.9

* Sign: + means above zero.
- means below zero.

2-27. *Wind data.* The wind direction may be reported to the nearest 5° by adding 0 or 5 to the hundreds digit of the speed, and the speed is reported to the nearest knot. For example, a wind direction of 295° and a speed of 45 knots is encoded as "29545." Remember the wind direction should be decoded to the nearest 5° by determining whether or not 500 has been added to the windspeed (fff). If it has been added, you add 5° to the value for "dd." This is how you can obtain a wind direction to the nearest 5°.

2-28. The values for "fff" are the windspeed. The values coded for "fff" need no conversion unless 500 is added to the windspeed to obtain wind direction to the nearest 5°. The wind group "29635," therefore, decodes as 295° at 135 knots.

2-29. *Tropopause data.* Part A includes a report of tropopause data providing that it occurs between the surface and 100 mb. Part C contains the tropopause data when it is above 100 mb. For purposes of illustration, suppose the tropopause occurs at 240 mb. This data would then appear in the first transmission, Part A.

2-30. A tropopause is represented by three groups of data. The data indicator 88 in the first group calls your attention to tropopause information. The remaining portion of the group, $P_tP_tP_t$, reports the pressure, in whole millibars, at the tropopause level. The second group reports temperature, $T_tT_tT_{at}$, and dewpoint depression, D_tD_t. Standard coding instructions apply to this group as for any temperature group at other levels. Standard coding also applies to the third group ($d_td_tf_tf_tf_t$) containing wind direction and speed. For similarity of data, the tropopause level can be compared to the surface. When no tropopause is observed within the stratum covered by Part A, an indicator group, 88999, appears in the message. However, if no tropopause data is coded, this indicates the data was not ready at collection time and should follow in a correction message later. Following the tropopause section of the message is another special data section—maximum wind data.

2-31. *Maximum wind.* The final section of Part A reports maximum wind. Aside from meeting certain criteria, the maximum wind must occur at or below 100 mb to be included in Part A. Two indicator figures, 77 or 66, identify this section. Indicator 66 places the maximum wind at the terminating level of the ascent. The 77 indicator tells you when the maximum wind occurs below the terminating level. The pressure at the maximum wind level follows. The second group, of course, reports the wind in the same way as for other levels.

2-32. There are four options for reporting maximum wind with which you should be familiar. Normally, two groups of data represent the wind level. Occasionally, a *secondary maximum* is also observed and reported, adding a second set of groups. If no maximum wind can be observed in the stratum included in Part A, the group 77999 appears in the report as the third option. Finally, when no maximum wind data is reported, you may assume the data was not available at collection time, but should follow in a correction message later.

2-33. From the temperatures and dewpoint depressions of Part A, a general picture of the sounding to 100 mb becomes evident. It remains for Part B to fill in the gaps showing the details of temperature inversions and upper layers of moisture.

2-34. **Part B (Radiosonde Code).** Unlike Part A, where the number of levels remains fixed, Part B contains as many levels as necessary to show the significant changes of temperature or humidity within the sounding. Significant changes in wind not being considered, no winds are reported. Though it accompanies Part A in the first transmission, Part B has its own identification section.

2-35. *Identification.* The two-letter message identifier, VV, appears first, The remaining groups, date/time and station number, are identical to Part A with but one exception. That exception is the wind indicator, I_d. Since no winds are included, I_d conveys no meaning for Part B. Therefore a solidus is always reported.

2-36. *Surface data.* A repetition of the surface, data, excluding winds, appears as the first level in Part B. Level indicator 00, instead of 99 as in Part A, indicates surface data and is not used for any other level in Part B. The type of data reported for other levels is consistent with the surface data, namely, pressure, temperature, and dewpoint depression.

2-37. *Significant levels.* Indicators assigned to each level and numbered in consecutive order maintain proper sequence. Even a level within a missing data stratum is assigned an indicator to show the existence of missing data. The numbering sequence begins with 11 for the first level above the surface and continues (22, 33, . . . 88, 99, 11) for subsequent levels. When missing data for a single level occurs, the bounding and missing levels appear in the message as: 44PPP TTT_aDD 55/// ///// 66PPP TTT_aDD. Of course, the letters would be represented by numbers in the actual report. The coding of individual elements follows the procedures outlined in preceding paragraphs. No significant levels for pressures lower than 100 mb are reported in Part B. *Two special data sections follow the significant levels in the report:* the 250-mb level and additional data.

2-38. *250-mb level.* At one time the 250-mb level was reported as a standard isobaric surface. The WMO regarded the level as less significant than formerly and decided to delete the requirement for reporting it in the international part (A) of the code. However, United States reporting stations retain the level, but it appears in the regional part (B) of the code as a separate section. The method of reporting 250-mb data resembles that of the standard isobaric surfaces. An indicator group, 31313, precedes the data. Then indicator height (25hhh), temperature/dewpoint depression (TTT_aDD), and wind (ddfff) groups complete the section. When 250-mb data are not observed, the entire section is omitted from the message. The final section of Part B and also the first transmission contains additional data.

2-39. *Additional data.* The indicator group, 51515, specifies that the following groups contain data in regionally adopted code forms. Region IV adopted the 101 groups. Various information that cannot otherwise be included in the message finds itself in the 101 group. You can locate the exact meaning of each 101 group in the *Manual for Radiosonde Code*. For example, 10143 = means observation delayed.

2-40. *Early transmission data.* The 850 =, 700 =, and 500-mb standard levels and stability index form an abbreviated report known as the *Early Transmission Message*. Coding of the standard levels follows the same rules outlined in Part A. These early messages are in addition to the complete report. The coded data for these levels in the complete report is in no way affected by the early message. A unique part of the early message is the stability index.

2-41. Stability index, I_sI_s, can be found only in the early message. The index implies the degree of stability for the stratum between surface and 500 mb. Stable conditions are reported by code figures 01 to 40 inclusive. Within that range the higher values indicate greater stability. Unstable conditions are indicated by the code figures 51 to 90 inclusive. When the index is unavailable, it is not reported. Since the stability index and the early transmission of standard level data fall into the additional data category, the entire message is assigned the 10196 identifier.

2-42. Each early message begins with an identification section, VV YYGG/ IIiii 51515. The 10196 identifier that follows shows that 850 =, 700 =, 500-mb levels and stability index data follow. Occasionally, one of the levels cannot be reported. Rather than burdening the message with a series of solidi, other 101 groups may be reported to show the omission. As an illustration, 10195 identifies data for 850- and 500-mb levels and stability index. Data for 700 mb being unavailable, the message completely omits the level. Code figure 10197 identifies data for 500 mb and stability index; 10198 identifies 700-mb data and stability index.

2-43. Though the early message has a Part B identification section, it is a separate message. It precedes the first transmission in time. Parts A and B make up the first transmission and contain the specific sections just discussed. Approximately 1 1/2 hours after the first transmission, the second transmission (Parts C and D) is transmitted via teletype circuits.

2-44. **Parts C and D (Radiosonde Code).** All mandatory levels above 100 mb are reported in Part C, and significant levels in Part D. Date coding is similar to Parts A and B. Only minor differences between reporting procedures need to be pointed out. Naturally, the message identifier is different. Part C is identified by WW. Also the wind indicator, I_d, though still a coded figure, indicates a standard level within Part C. The part D message identifier is YY.

2-45. Other deviations exist in the way heights, hhh, and pressures, PPP, are reported. All heights are in meters and show the thousands, hundreds, and tens digits. Therefore, a height of 18,510 meters becomes a code value of 851. Pressures are reported in tenths of a millibar. This becomes important in Part C only for reporting tropopause or maximum wind pressure levels and applies to the Part D significant levels.

2-46. When the tropopause section in Part A is coded 88999, you may expect tropopause data in Part C. Similarly, you expect maximum wind data in Part C when 77999 is coded in Part A. When a code of 88999 in Part C appears as well, no tropopause can be determined. A similar rule applies to maximum wind. Neither tropopause or maximum wind data can be coded in Part C unless they occur at a pressure level less than 100 mb.

2-47. The last information that can be added to Parts B or D, wherever it applies, is the plain language data concerning a superadiabatic lapse rate. Plain language data always follows the 51515 indicator used for 101 groups. The contraction SUPER identifies superadiabatic lapse rates. Either of the following formats may be reported: 51515 $101A_{df}A_{df}$ SUPER P_BP_B-P_TP_T, or 51515 SUPER P_BP_B-P_TP_T. The latter example indicates a superadiabatic lapse rate without a 101 group. Bounding levels of the layer are shown by P_BP_B (base) and P_TP_T (top). They represent the pressures in tens of millibars (Part B) or whole millibars (Part D).

2-48. When both transmissions (all four parts) are considered together, they complete the TEMP (land station) form of radiosonde code. Ship stations taking upper air soundings code their data in TEMP SHIP form. The TEMP SHIP message comes in four parts and is identical to TEMP in code format, data reported, and transmission arrangement. The only noticeable difference you can find between TEMP and TEMP SHIP messages is in the identification section.

2-49. **TEMP SHIP (Radiosonde Code).** The geographical and station numbering of ship stations cannot be easily expressed by an IIiii group as in the TEMP code. Instead, the ship's latitude, longitude, and Marsden Square number replace the IIiii in the identification section. Three groups contain location information. Following the message identifier and date/time groups, which resemble their counterparts in TEMP code, is the first of the three groups—latitude.

2-50. The latitude group, $99L_aL_aL_a$, reports ship position between the equator and the pole to the nearest 0.1° latitude. Longitude and quadrant of the globe are coded in the second group, $Q_cL_oL_oL_oL_o$. Without direction designators you would find it difficult to determine whether latitude was north or south and longitude was east or west. However, the coded quadrant figure Q_c, indicates both. Mentally slice the globe into four parts; once at the equator, dividing north and south, and again at the 0°/180° meridian, dividing east and west. From table 12, Q_c code figures define each quadrant. Quadrant 7 locates ships navigating the waters bordering all sides of North America. When Q_c appears as 7, you know at once that the latitude is north and longitude is west. An exact position can then be found using the reported latitude and longitude. Longitude also appears to 0.1°.

TABLE 12
SYMBOL Qc

Code Figure	Latitude	Longitude
1	North	East
3	South	East
5	South	West
7	North	West

2-51. Though the latitude and longitude groups sufficiently pinpoint the ship location, the third group, Marsden Square number, verifies the position given in the first two groups. Since plotting positions are determined from latitude-longitude, you or your plotters have limited need for the Marsden system. Figure 4 shows the Marsden number represented by MMM in the code. Each 10° Marsden Square is divided into 1° subsquares. The $U_{La}U_{Lo}$ figures give the number of the subsquare within the Marsden and incidentally coincide with the units digits of both the latitude and longitude. Suppose a ship's location appeared in the $MMMU_{La}U_{Lo}$ group as 08823. From figure 4 you can place the ship north of the Hawaiian Islands at 22° N. and 150° W. The remaining elements of TEMP SHIP code bear no difference from TEMP code. Ships even transmit early data messages. Thus, since further discussion of TEMP SHIP decoding would be repetition, let us shift emphasis from decoding radiosonde reports to the upper wind code. To obtain a more complete picture of the vertical wind field, the upper wind code complements the radiosonde code by providing wind data for additional levels.

2-52. **Upper Wind Code.** The code name "PILOT" refers to the upper wind report from a land station. The form of the code used by ships in reporting upper wind observations differs from the form used by land stations only in regard to the identification data. Just as in TEMP SHIP the "IIiii" identifier is replaced by the groups "$99L_aL_aL_aQ_cL_oL_oL_oL_o$ $MMMU_{La}U_{Lo}$." Upper winds serve for plotting station continuity charts, winds aloft maps, specific level winds on the Skew-T, and gradient winds. Since a radiosonde sounding furnishes upper winds, both PILOT and TEMP codes may be derived from a single sounding. In this way duplication of observation and coding can be avoided. Like TEMP code, four parts (A, B, C, and D) divide the upper wind code.

2-53. These parts possess the same characteristics for collection and distribution, level orientation, and stratum coverage as the TEMP code. Parts A and B are collected together, Part A being intended for worldwide distribution. Part A contains winds for standard isobaric levels; Part B furnishes winds at significant and fixed regional levels. Parts A and B cover the stratum between the surface and 100 mb.

2-54. Upper wind data are normally available four times daily beginning at 0000 GMT at 6 hourly intervals. At those times when the wind observation coincides with radiosonde reporting (0000 and 1200Z), the upper winds are attached to the radiosonde report. Because of this grouping together, Part A PILOT becomes unnecessary, since it duplicates wind data reported in Part A TEMP. This is also true for Part C PILOT and TEMP in the second transmission. The complete code is outlined here in much the same manner as the radiosonde code. The format below illustrates symbolically the four parts of the code.

PART A:

PP YYGGa_4IIiii (Identification—Section 1)

$44NP_1P_1$
or
$55nP_1P_1$ ddfff ddfff ddfff

----- ----- ----- ----- (Mandatory Isobaric Surfaces—Section 2)

$44nP_1P_1$
or
$55nP_1P_1$ ddfff ddfff ddfff

$77P_mP_mP_m$
or
$66P_mP_mP_m$ $d_md_mf_mf_mf_m$
or
$7H_mH_mH_mH_m$
or
$6H_mH_mH_mH_m$ $d_md_mf_mf_mf_m$ (Maximum Wind Data—Section 3)

PART B:

QQ YYGGa_4 IIiii (Identification—Section 1)

$9t_nU_1U_2U_3$ ddfff ddfff ddfff

----- ----- ----- ----- (Fixed Regional Levels and Significant Levels—Section 4)

$9t_nU_1U_2U_3$ ddfff ddfff ddfff

Symbol MMM = Number of Marsden Square for the Ship's Position at the Time of Observation

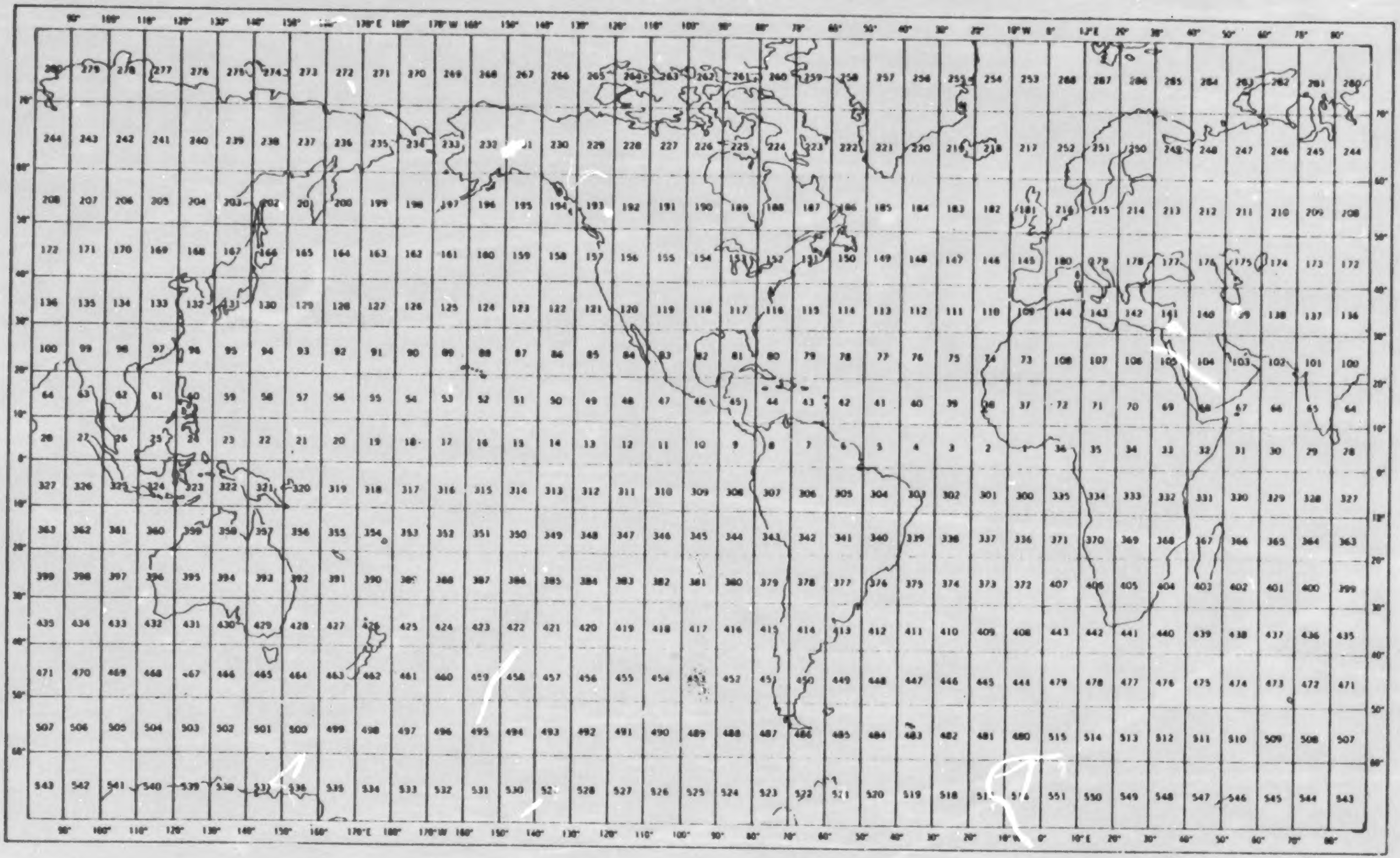

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Figure 4. Symbol MMM.

PART C:

MM $YYGGa_4$ IIiii (Identification—Section 1)

$44nP_1P_1$ or $55nP_1P_1$ ddfff ddfff ddfff

----- ----- ----- ----- (Mandatory Isobaric Surfaces—Section 2)

$44nP_1P_1$ or $55nP_1P_1$ ddfff ddfff ddfff

$77P_mP_mP_m$ or $66P_mP_mP_m$ $d_md_mf_mf_mf_m$

or

$7H_mH\ H_mH_m$ or $6H_mH\ H_mH_m$ $d_md_mf_mf_mf_m$

PART D:

LL $YYGGa_4$ IIiii (Identification—Section 1)

9 or 8 $t_nU_1U_2U_3$ ddfff ddfff ddfff

----- ----- ----- ----- (Fixed Regional Levels and Significant Levels—Section 4)

9 or 8 $t_nU_1U_2U_3$ ddfff ddfff ddfff

2-55. *Identification code.* The identification code, with the exception of the two-letter message identifier, is identical for all parts of the code. Date-time data (YYGG) gives you the same information as in radiosonde code, including the unit of measurement for windspeed. Code figure a_4 in the date-time group relates to the method of obtaining winds reported in the code. The meaning of the code figures for a_4 are listed as:

Code Figure	*Equipment*
0	Pressure instrument associated with wind measuring equipment
1	Optical theodolite
2	Radio theodolite
3	Radar
4	Pressure instrument associated with wind measuring equipment, but pressure element failed during ascent.

The type of observing equipment used is also reflected in the indicator for mandatory levels discussed in the next topic.

2-56. *Types of levels.* The *mandatory levels* are the same standard isobaric surfaces reported in radiosonde code. Quantitative changes in direction or speed appear in the code as significant levels. Added to these two types are fixed altitude levels included by regional agreement. Parts A and C contain the mandatory levels with the 100-mb level as the dividing level. Since these winds are included in Parts A and C of the radiosonde code, Parts A and C of the upper wind code are normally not used in Region IV. Parts B and D contain the fixed altitude levels with significant levels placed between. Whenever a fixed altitude level closely approximates the height of a mandatory level, the report omits the fixed altitude level: This explains why 5000 feet (850 mb) and 10,000 feet (700 mb), for example, do not appear as fixed altitude levels.

2-57. The *standard isobaric levels* use an indicator group ($55nP_1P_1$ or $44nP_1P_1$) to introduce a series of mandatory levels. When the mandatory levels are located by means of pressure measuring equipment (a_4 of "0"), 44 is reported. When winds are reported at altitudes approximating the standard isobaric surface heights (a_4 of "1–4"), 55 is reported. The digit reported for "n" reveals the number of surfaces reported in series and cannot exceed three. P_1P_1 is a pressure indicator for the first level of the series. An indicator group 44385 tells you that the levels are located by pressure measurement (44), three mandatory levels are included in the first series, and the first level of the series is at 850 mb (85). The three wind groups that follow the indicator are coded in "ddfff" form and represent the winds for the 850=, 700=, and 500-mb mandatory pressure levels.

2-58. The *significant and fixed altitude levels* are the levels in Part B which are also preceded by an indicator group. The key to decoding the data in this section is the "$9t_nU_1U_2U_3$" group. The first digit, "9," is an indicator identifying the group and specifying that the levels reported are below 100,000 feet and the altitude figure is expressed in 1000-foot increments. The "t_n" element specifies the altitude in tens of thousands of feet of the winds reported in the following three groups. In effect, this means that a "t_n" coded as "0" refers to winds below 10,000 feet. If "t_n" is coded "1," the base level of the winds reported in the data groups is 10,000 feet; a "t_n" of "2" means a base level of 20,000 feet, and so on up to 90,000 feet. The figures coded for "$U_1U_2U_3$" specify the units digits of the wind levels in increments of 1000 feet for the three successive levels. For example, a "$9t_nU_1U_2U_3$" group coded as "91246" indicates that the wind data are for 12,000, 14,000, and 16,000 feet.

2-59. The three data groups that follow the "$9t_nU_1U_2U_3$" group are, again, encoded the same as wind data groups in the radiosonde code. However, there may not always be three data groups. If the "$9t_nU_1U_2U_3$" group is used to report less than three levels, solidi (/) are coded in the group for "U_2" and "U_3" as appropriate. For example, if the termination of the sounding occurred at 98,000 feet, the group "998//," followed by the wind data group, would be the proper method of encoding this information. As a matter of fact, the wind at termination is always included as the last significant level, just as the wind at the surface is always encoded as the first significant level.

2-60. The group "$9t_nU_1U_2U_3$" used in Part B may take on a slightly different form in Part D. The "9" indicator specified that the levels reported in Part B were below 100,000 feet, and that the altitude figure was expressed in increments of 1000 feet. If the ascent extends to 100,000 feet and higher, the indicator "8" is used instead of the "9." The indicator "8" specifies that the levels reported are 100,000 feet or above and are expressed in increments of1500 feet.

2-61. *Maximum winds.* Part A contains the reporting of maximum wind data. One of two possible methods is used in reporting maximum wind data. The format "$77P_mP_mP_m$" or "$66P_mP_mP_m$" represents one method and "$7H_mH_mH_mH_m$" or "$6H_mH_mH_mH_m$" a second method. The method used depends entirely upon whether the level of maximum wind was determined by pressure measurement ($P_mP_mP_m$) or by means of a height computation ($H_mH_mH_mH_m$).

2-62. The data reported for "$P_mP_mP_m$" represents the pressure at the level of maximum wind. Up to and including 100 mb the pressure is reported to the nearest whole millibar, and to the nearest tenth of a millibar above 100 mb. When pressure data are not available, the level of the maximum wind is reported with respect to a computed altitude, represented by "$H_mH_mH_mH_m$. The altitude is reported in increments of 30 feet. For example, if the code figure 1400 is reported, the true altitude can be obtained by multiplying the reported value by 30 (1400 × 30 = 42000 feet).

2-63. The indicators "66" (or 6) and "77" (or 7) express the same meaning as in the radiosonde code. The maximum wind group "$d_md_mf_mf_mf_m$" decodes the same as any wind group. If the maximum wind was not observed, the indicator group "77999" is inserted to give positive notification that the maximum wind data are not available.

2-64. Now that we've reviewed both code types, we are going to discuss the products obtained by using these codes. Two products to which radiosonde reports contribute are constant pressure charts and thermodynamic diagrams (Skew-T diagram). Our discussion shall deal with the plotting of these two charts.

2-65. **Constant Pressure Charts.** Where facsimile transmission is available, there is little need for plotting constant pressure charts. However, the need for plotting such charts still exists at many locations and at centralized weather facilities.

2-66. *Plotting model.* A plotted constant pressure model presents no great challenge since the amount of data reported for each isobaric level is confined to four parameters—height, temperature, dewpoint depression, and wind direction and speed. Turn to foldout 6, and follow the symbolic format and plotting model as we discuss them in the text. Foldout 6 illustrates the plotted models

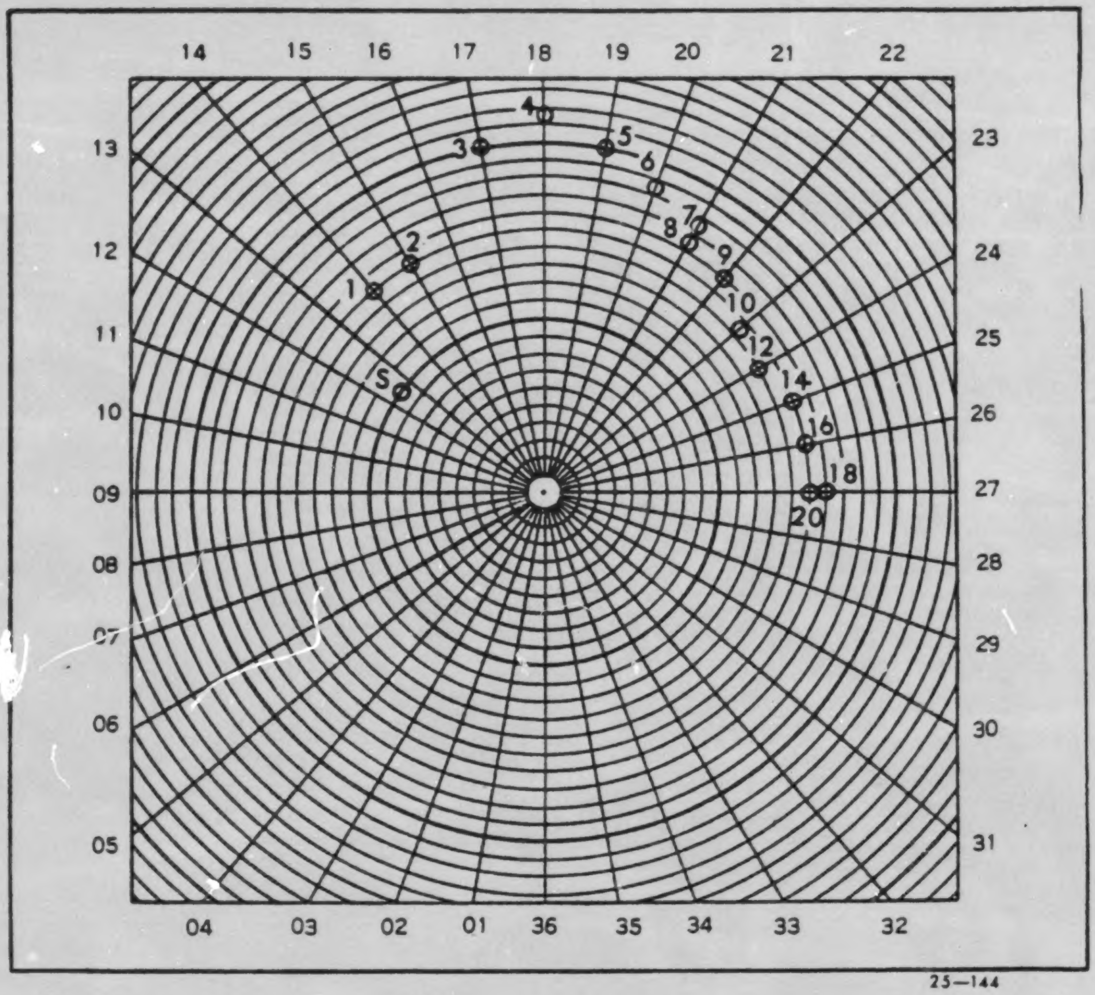

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Figure 5. Plotted hodograph.

both in symbolic and numerical forms. From general observation you notice a darkened station circle, wind direction indicator, and whole degrees for temperature and dewpoint depression. Looking specifically at temperature and depression for the 850-mb level, you find that both have been rounded to whole figures according to standard rules—temperature from 2.2 to 2, and depression to 11 (61 – 50 = 11). The depression at 700 mb is not rounded off, as it is already reported in whole degrees (67 – 50 = 17). The darkened circle correlates with the plot whose depression is 5° or less. An open circle correlates with the greater depressions. The darkened circles emphasize areas of high moisture.

2-67. *Plotting rules.* Some basic rules governing special situation plotting need mentioning. Inclose doubtful data in parentheses. Plot M for a missing parameter, except windspeed and direction when both are missing. If a portion of the reported element is garbled or missing, plot X for each missing digit. Show a missing wind direction by plotting an X in a break in the wind shaft. The plotter judges the best directional position of the wind shaft. An X plotted at the end of the wind shaft means missing windspeed. Extrapolated height data is to be underlined. A circle drawn around the station shows a calm. These rules are generally addepted and employed, though deviations may exist. Most vital to the completed chart is that whatever is plotted should convey the same meaning to everyone using the data.

2-68. In the area of decoding, one frustrating situation occurs when a string of letters garbles the report. Often, the letters can be converted to numbers and prevent loss of data. A proficient plotter has the conversion of QWERTYUIOP to its numerical equivalent (1, 2, 3, 4, 5, 6, 7, 8, 9, 0) committed to memory or handily available. Another decoding skill aimed at increasing plotting speed is the quick location of data within the report. For instance, 500-mb data most frequently appears in the middle of the second line in the report. Knowing this location cuts search time.

2-69. **Thermodynamic Diagrams.** The thermodynamic diagram (Skew-T) is a commonly plotted chart used by weather personnel. The number of these charts required depends upon sources of data, season, and the extent of the desired analysis. In normal operations, one chart is used for each reporting station, and not more than two soundings of new data are plotted on it.

2-70. When preparing a Skew-T chart, enter a trace from the previous sounding on the chart for continuity. A 12-hour interval between reports permits the forecaster to see on one chart the atmospheric changes that occur at a particular station. Trace the temperature and dewpoint curves from the preceding (continuity) sounding in black ink or pencil without transcribing data or circling any point. Usually you do this before plotting the first new sounding. Plot the sounding that is 12 hours after the black continuity trace in blue pencil, and plot the sounding that is *24 hours* after the *black trace* in *red* pencil. This plotting method allows the use of red for the third set of curves to emphasize the latest data.

2-71. A free air temperature curve and a dewpoint curve are plotted for each sounding. Locate the points to be plotted for each sounding. Locate the points to be plotted on the chart by referring to the pressure and temperature (free air or dewpoint) of the level. Plot dewpoint temperatures after subtracting the dewpoint depression from the free air temperature. A plotting template is available for this purpose. Indicate the temperature and dewpoint by a small dot located at the appropriate pressure level. Draw a small circle of approximately 1/8 inch diameter around each dot on the temperature and dewpoint curves. This circle will aid in locating the points when you draw the connecting lines. The circle further aids in identifying significant points on the curves. Always represent the free air temperature curve by a solid line and the dewpoint curve by a dashed line. Identify superadiabatic lapse rates by entering "SUPER" near the curve and drawing lines to its boundaries.

2-72. To show temperature and dewpoint curves through strata of doubtful data, draw them in the normal manner; however, the limits of these strata must be indicated in the space above the legend at the bottom right of the diagram (e.g., TEMP DBTFL 610−550 MB) in the same color that you use for plotting the curves. Where there is a stratum of missing data, end the curves at the lower boundary of the stratum and start the curves again at the upper boundary of the stratum. Enter the symbol "MISDA" in the middle of the stratum of missing data in the same color you use for plotting the curves. "MISDA" is also entered whenever a stratum contains no dewpoint data and the air temperature is warmer than −40° C. Since dewpoint data are not encoded for air temperatures colder than −40° C., no plotted remark is necessary for missing dewpoint data above that point.

2-73. For levels from 1000 to 100 millibars, enter the height of each mandatory level on the isobar to which it pertains just inside either edge of the diagram. Enter the heights for levels above 100 millibars just inside the right edge. If necessary, adjust the position of height entries to avoid conflict with other plotted data. Enter all height values to the nearest meter for levels up to 500 millibars and to the nearest 10 meters for levels at 500 millibars and above.

2-74. Plot wind data at the mandatory levels in the same color as the corresponding sounding curves, using wind shafts and barbs. Plot wind data at other levels, taken from the upper wind report for the same time, on the solid dots. Plot these reports in the same manner as you would plot winds on surface charts (north is at the top of the diagram, a full barb equals 10 knots, etc.). Use the right-hand staff for the first wind report, and plot succeeding reports on the middle or left-hand staff. Usually you do not copy the winds for the continuity trace unless the forecaster specifically asks for them, in which case they are plotted on the right-hand staff.

2-75. For identification, enter a legend for each sounding that is plotted. Station index number (or location identifier), station name, and time and date (GMT) complete the legend. Use the same color for legend entries that you use for the corresponding sounding curves. When a schedules sounding is not received, complete the legend entries and enter the "101" group, identifying the reason for no observation in the space above the legend in the appropriate color. If a "101" group is not received, enter "____Z MISG."

2-76. From the foregoing discussion you can see that the radiosonde code reports a rather complete picture of the atmosphere in terms of pressure, temperature, and moisture. However, you shouldn't overlook the value of the data provided by the upper wind information.

2-77. Wind data becomes useful in several ways. It can be presented to show wind flow on a horizontal plane over a large area; it may show a vertical distribution over a single location; or indicate wind flow with passage of time at a station. One example of each of these presentations will now be discussed.

2-78. **Winds Aloft Chart.** The depiction of the wind field over a large horizontal area describes a winds aloft chart. Facsimile transmission of these charts, representing several different horizontal levels, usually satisfies the operational need. The forecaster uses data concerning these winds for flight briefing purposes or as a limited forecasting and analysis tool. For example, a winds aloft chart plotted from data 6 hours later than the latest constant pressure data indicates changes in a trough or low-pressure circulation from purely wind-field considerations. Therefore, the forecaster is aware of a deepening trough or low-pressure development before receiving the subsequent constant pressure data.

2-79. **Hodograph Chart.** A hodograph chart shows the vertical distribution of winds above an observation point. Figure 5 illustrates a hodograph. Lines radiating from the center represent direction; the concentric circles show speed. Labels for plotted points indicate height. Note the reversed numbering of the direction lines. This numbering aids the analysis by showing wind direction originating from the point of observation rather than from a compass point. Hodograph data provides the forecaster with a means of deriving thermal wind data from which the intensity of the front may be determined.

2-80. Refer to your workbook and answer the chapter review exercise items for Section 2.

3. Aircraft Codes

3-1. On a routine basis, *usually* daily, and mainly over the ocean areas of the world, AWS reconnaissance aircraft observe and report weather phenomena that would otherwise go undetected. These efforts, on the part of our "*airborne weathermen*," provide weather data to fill the gaps that exist over sparse data areas. Without these aircraft reports many predictions of weather systems and their meteorological effects would be left to pure guesswork.

3-2. In addition to the scheduled aircraft weather observations (RECCO, COMBAR, and AIREP), military and civilian aircraft report observations while in flight over the ocean expanses, even though their mission is nonweather. These observations are reported in PIREP code form. Naturally, if you are assigned to a coastal region or weather center, you are exposed to aircraft codes more than if you are assigned to a smaller detachment in the central United States. If you understand these aircraft codes and the way aircraft reports can be included in the station map plotting operation, it should enable you to perform more effectively as an observer.

3-3. Aircraft codes have many uses in AWS. Weather centers rely heavily upon aircraft reports to complement the weather coverage provided by radiosonde observations at land stations. By interpreting the weather elements reported by aircraft in flight along the appropriate upper air chart, the forecaster can complete a satisfactory chart analysis. RECCO code is a highly reliable and important code, since the flight tracks are schedules over remote areas, and the forecaster can expect specific weather information.

3-4. **RECCO Code.** Using foldout 7 follow along the symbolic format and plotting guides as we discuss RECCO code in more detail. For normal station operations, only certain groups of this code form are used; therefore, our discussion is limited to these groups.

3-5. Identification and time groups (9XXX9 GGggi$_u$). The first group of RECCO code is an identification group and is usually located at the start of each RECCO teletype collection. The three middle digits (XXX) are useful in determining the units used and whether or not radar data is available. The numbers reported for "XXX" indicate the following:

111	Height in feet MSL.
222	Without radar—height in meters.
333	Pressure data (millibars).
444	Not used.
555	Not used.
666	Height in feet MSL.
777	With radar—height in meters.
888	Pressure data (millibars).
999	Not used.

3-6. The time group, GGggi$_u$, gives time in hours (GG) and minutes (gg) of the observation at the position indicated by the latitude and longitude groups. All reported elements in the code are measured or observed as near as possible to this time. The last digit (i$_u$) provides information on the moisture or humidity data reported. AWS aircraft report dewpoint so that (i$_u$) is coded as a 4 (when dewpoint is available) or 0 (when it is not). AWS aircraft do not use code figures 1, 2, or 3.

Code Figure	*Units*	*Humidity*
0	°C	No humidity available.
1	°C	Relative himidity, %.
2	°C	Wet bulb depression.
3	°C	Dewpoint depression.
4	°C	Dewpoint.

3-7. *Latitude and longitude groups* ($YQL_aL_aL_a\ L_oL_oL_oBf'_c$). To insure that the observers plot RECCO reports at the correct location, you must periodically check the plotted stations. The first digit (Y), represents the day of the week, numbered from "1" to "7" beginning with Sunday. The second digit (Q) reveals the aircraft location according to the octant of the globe. If your station plots RECCO reports, a table for the globe octants should be posted near the plotting desk as follows:

Code Figure	*Longitude*	*Hemisphere*
0	0° – 90° W.	Northern
1	90° W. – 180°	Northern
2	180° – 90° E.	Northern
3	90° E – 0°	Northern
4	Not used	
5	0° – 90° W.	Southern
6	90° W. – 180°	Southern
7	180° – 90° E.	Southern
8	90° E. – 0°	Southern
9	Not used	

3-8. The last three digits ($L_aL_aL_a$) are the latitude to the nearest tenth of a degree. The first three digits ($L_oL_oL_o$) of the following group give the longitude in tens, units, and tenths of degrees. For example, a position of 168.5° west longitude is coded "68.5." The octant code "1" or "6" tells you that it is 168.5° rather than 68.5°.

3-9. The last two digits of the longitude group provide turbulence (B) and flight condition (f'_c) data. When other than code figure "0" is reported, the true airspeed of the aircraft is reported in plain language at the end of the report, for example, "TAS460." The turbulence value is a coded digit that indicates the severity of turbulence; the higher numerical values indicate more severe turbulence. The value reported for the flight condition tells the forecaster the amount of cloud cover above, at, and below the flight level. The group that follows the longitude group contains information that you should not ignore when you check the RECCO report plotting.

3-10. *Altitude of aircraft* ($hhhd_td_a$) The first three digits (hhh) tell the aircraft altitude at the observation time. The height is reported in decameters. For example, 6970 meters is reported "697," and 10520 meters, "052." The value reported for "d_t" is very important because it indicates to the plotter whether or not the winds are at the point of observation. When "d_t" is coded as a solidus "/," and d_a is coded as an "8," the wind group will be coded as "/////." The "8" for d_a means the navigator was unable to determine any type of wind. In this case, the plotter must be careful *not* to plot the temperature group as a *wind* group.

3-11. *Wind (ddfff).* The wind group of RECCO code reports the direction (dd) in tens of degrees ("01" is 5° to 14°) and the speed (fff) to the nearest knot. If the direction is variable, "99" is reported. If the wind is calm, "00" is coded for direction.

3-12. *Temperature and weather* (TTT_uT_uw). The temperature (TT) is the temperature at flight level and is reported to the nearest degree Celsius. Negative temperatures are coded with "50" added to the temperature. For example, −18° Celsius is "68" in the coded message. Depending on the coded value reported for "i_u" in the second group, "T_uT_u" is dewpoint depression, relative humidity, or dewpoint temperature data. Dewpoint temperatures are coded the same as temperatures. The last digit (w) of the temperature group indicates the general classification of weather at the flight altitude.

3-13. *Height data (mjHHH).* The first digit (m) of this height group provides a more detailed picture of the weather type. For instance, code value "5" refers to "heavy continuous." If this intensity classification is used with rain, it means heavy continuous rain. The value reported for "j" is important in that it is a code value that is used to identify the proper constant pressure level for the observation. The levels for the code values for "j" are as follows:

Code Value	*Pressure Level*
0	MSL
1	1000 mb
2	850 mb
3	700 mb
4	500 mb
5	300 mb
6	200 mb
7	100 mb
8	True altitude minus pressure altitude (D-value, in decameters) recorded by pressure altimeter set at 29.92.
9	No radio altimeter subscale reading in millibars (thousands figure omitted).

3-14. After you have determined the correct standard constant pressure level, you only need to know what the value for "HHH" represents. You already know that the indicator group, 9XXX9, specifies what height units are used. In most cases, metric units are used; therefore, the data reported for "HHH" is the height in meters or tens of meters of the constant pressure level. If the report is for the surface, 1000-mb, 850-mb, or 700-mb level ("j" values of 0, 1, 2, or 3), the height is reported to the nearest meter. For higher levels, each height is reported to the nearest ten meters, with the tens of thousands figure omitted. For instance, if the report is for the 300-mb constant pressure surface and the height is determined to be 10,200 meters, the entry for "HHH" is "020." When the radio altimeter is inoperative and 9 is encoded for "j," the "HHH" is coded as "013."

3-15. *Cloud data* ($1K_nN_1N_2N_3$ *ChhHH*). The cloud code groups are always identified by the "1" indicator. They are of great importance to the forecaster if he is investigating the movement of storms or is preparing a cloud analysis and weather depiction chart. The digit is reported for "K_n" is a key digit, since it reveals the number of cloud layers to be reported with the observation. The following three digits (N_1, N_2, and N_3) are the amount of sky covered, in eighths, by each layer. When more than three layers are reported, an additional "1" group is sent to report the amounts of the additional layers. For example, an observation that reports five cloud layers contains the following cloud data:

15336 ChhHH ChhHH ChhHH 12120 ChhHH ChhHH

The coverage amount for each of the five layers is 3, 3, 6, 1, and 2 eighths respectively. Notice that the second "1" group reports only data for the two additional layers. The actual cloud types and their heights are sent in five-digit groups following the "1" indicator groups.

3-16. Each cloud type (C) is coded according to international coding instructions for the ten basic cloud forms which are in Volume 2. Foldout 1 contains the code value for each cloud type. The heights of the bases and tops are also reported, using international rules for coding cloud heights (such as used with "8" indicator groups of synoptic code). For example, if a cloud layer of stratocumulus with bases at 2900 feet and tops at 6000 feet is present along with a layer of altostratus with bases of 17000 feet and tops at an unknown height, the cloud group is coded "61956 467//."

3-17. Special rules or exceptions concerning the cloud groups should always be considered.

- When the sky is chaotic, "K_n" is coded "9," and the code for "N" represents the total sky cover.
- When it is impossible to determine the presence of clouds, because of darkness or other reasons, the value for "K_n" is reported as "/" (solidus).
- When one or more cloud layers are dimly discernible, and type, amount, and height are unknown, "K_n" is reported "1" to indicate that clouds are present, but the amount (N_1) is coded "9" with the following cloud group coded "/////."
- When the presence of clouds below the aircraft cannot be determined, and it is obvious that no clouds exist about the aircraft, the "1" group is coded "1/990."

3-18. *Surface wind data (4ddff or* $5DFSD_k$*).* These two groups are never sent for the same observation. In addition, they are transmitted only when the observation is at or below the 700-millibar level. The "4" indicator group reports the direction from which the surface wind is blowing in tens of degrees (dd) and the windspeed in knots (ff). If the speed is 100 knots or more, 100 is subtracted from the speed and 50 is added to the direction. For example, a wind from 270° at 164 knots is coded "47764" in a RECCO report. When speeds are in excess of 199, "ff" is reported "//" and a plain language remark, such as "WIND 205" is added to the report.

3-19. The "5" indicator group reports the surface wind direction (D) to eight points of the compass.

Code Figure	*Direction*
0	Calm
1	NE
2	E
3	SE
4	S
5	SW
6	W
7	NW
8	N
9	All directions, no definite direction, unknown, or no report.

The surface wind force (F) is coded along the lines of the Beaufort wind scale. This means the higher the coded value, the larger the ocean waves and crests, hence, the higher the surface windspeed. For example, a value coded "6" for the force (F) means *large waves begin to form; the white foam crests are more extensive everywhere (probably some spray).* The forecaster's concern, naturally, is the force of the surface wind. From the condition stated above for a code value of "6" the forecaster can judge the windspeed to be approximately 22–27 knots.

3-20. The next digit of the "5" indicator group provides information on the state of the sea (S) as follows:

Code Figure	*State of Sea*
0	Calm-glassy
1	Calm-rippled
2	Smooth wavelets
3	Slight
4	Moderate
5	Rough
6	Very rough
7	High
8	Very High
9	Phenomenal

3-21. The last element of this group, the direction of swell (D_k), reports the direction from which the sea swell is moving with respect to true north. The coded values for "K_k" use the same direction units that are reported for the surface wind direction (D). The remaining groups of RECCO code are used very little in normal operations; therefore, you need only to understand the basic facts concerning each element, as explained in the following paragraphs.

3-22. *Remaining groups* ($6W_sS_sW_cD_w$ $7I_r$ ${}_tS_bS_e$ $7h_ih_iH_iH_i$ $8d_rd_rS_r0_e$ $8_ea_ec_ei_e$). The "6" indicator group is transmitted with the observation whenever significant weather changes occur. The value reported for "W_s" reveals significant weather changes that have occurred since the last observation, or in the preceding hour (whichever period is shorter). The code figures are as follows:

Code Figure	*Significant Weather Change*
0	No Change
1	Marked Wind shift
2	Marked turbulence begins or ends
3	Marked temperature change (not with altitude)
4	Precipitation begins or ends
5	Change in cloud forms
6	Fog bank begins or ends
7	Warm front
8	Cold front
9	Front, type not specified

3-23. The digit reported for "S_s" indicates the direction of the significant weather changes from the observation point.

Code Figure	*Distance*
0	No report
1	Reported at previous position
2	Occurring at present position
3	20 nautical miles
4	40 nautical miles
5	60 nautical miles
6	80 nautical miles
7	100 nautical miles
8	150 nautical miles
9	More than 150 nautical miles

3-24. The next digit, Wc, reveals weather phenomena that is observed off course.

Code Figure	*Weather Off course*
0	No report
1	Signs of hurricane
2	Ugly threatening sky
3	Duststorm or sandstorm
4	Fog or ice fog
5	Waterspout
6	Cirrostratus shield or bank
7	Altostratus or altocumulus shield or bank
8	Line of heavy cumulonimbus
9	Cumulonimbus heads or thunderstorms

3-25. The last digit (D_w) of the "6" indicator group gives the bearing of weather off course. "D_w" uses the same coded directions as the surface wind direction (D) reported in the "5" indicator group (code value of 5 = SW direction). Code figure 0 is used for D_w when Wc is reported as 0.

3-26. The "7" indicator group identifies the rate (I_r), type (I_t) of icing, and the location (S_bS_e) of the icing. This data is represented symbolically by the group "$7I_rI_tS_bS_e$" and is always the first "7" indicator group. The next group ($7h_ih_iH_iH_i$) indicates the height of the base and top of the icing layer. The first two digits after the "7" indicator represent the height of the icing base and the last two digits represent the top of the icing layer. In both cases, the heights are reported by using the same coding instructions that are used for reporting cloud heights of the ten basic international cloud types.

3-27. The last groups of RECCO code, when transmitted, are groups reporting radar data. This data is identified by the indicator "8." The next two digits (d_rd_r) give the bearing of the center of the echo from the aircraft in tens of degrees. For example, an echo at a bearing of 320° is reported "32." Some exceptions to the rule are:

- When echoes are in all directions, "99" is reported.
- When the distance to the center of the echo is greater than 95 nautical miles, "50" is added to the d_rd_r" and the tens value of the distance is entered for "S_r." For example, an echo 150 miles from the aircraft on a bearing of 280° is coded as 785 for $d_rd_rS_r$.

3-28. The distance to the echo center is reported in tens of nautical miles. When the distance exceeds 94 miles, a remark is entered with the observation, such as "RADAR AXIS 150 NM." The last digit of the first "8" group (0_e) describes the orientation of a line of echoes. The second "8" group ($8w_ea_ec_ei_e$) provides the forecaster with a better idea of the character and intensity of the echoes. The first digit (w_e) reports the width of the ellipse inclosing a line of echoes or the diameter of a circular echo in tens of nautical miles. The next digit (a_e) reports the length of a line; or, if a circular area, reports the diameter of the area in tens of nautical miles.

3-29. The value reported for "c_e" describes the character of the echo according to the following code.

Code Figure	*Character of Echo*
0	Indeterminate or not reported
1	Scattered
2	Solid
3	Scattered line
4	Solid line
5	Scattered, all quadrants
6	Solid, all quadrants

7	Not used
8	Not used
9	Not used

3-30. The last digit (i_e) describes the intensity of the echo according to the following code.

Code Figure	*Intensity of Echo*
0	No report or unknown
1	Weak, decreasing
2	Weak, no change
3	Weak, increasing
4	Moderate, decreasing
5	Moderate, no change
6	Moderate, increasing
7	Strong, decreasing
8	Strong, no change
9	Strong, increasing

One of your tasks in a weather unit may be to plot the RECCO collections; therefore, let's examine the various plotting models.

3-31. To supplement coded RECCO messages or supply additional information, plain language may be inserted at the end of the message. All RECCO observations transmitted by AWS aircraft *must have* coded inflight visibility appended in plain language remarks. Format is as follows:

Remark	*Visibility*
VSBY 1	Inflight visibility 0 to 1 mile.
VSBY 2	Inflight visibility 1 to 3 miles.
VSBY 3	Inflight visibility greater than 3 miles.

3-32. **RECCO Code (Plotting).** Referring to the right-hand corner of foldout 7 you'll note that there are three standard plotting models used for plotting RECCO observations.

- Complete model.
- Abbreviated model.
- Constant pressure model.

For normal map plotting operations, it is unlikely your detachment will ever have a need to plot the complete model of RECCO code; therefore, your station will have a plotting model indicating what is desired in your unit. Usually the abbreviated model is used when plotting RECCO observations on the surface chart. In addition to RECCO reports, COMBAR reports provide another source of weather information over sparse data areas of the world.

3-33. **COMBAR Code.** COMBAR code is primarily a voice code used by aircrews to provide operationally significant weather information. If your station receives COMBAR reports, you must be familiar with the incoming COMBAR code. This is necessary because COMBAR reports are processed by computers; therefore, the slightest deviation from the standard format prevents automatic decoding by the computers.

3-34. The following guidelines list some of the things you should do to screen COMBAR reports in addition to properly coding each report. Eliminate reports that:

- Are older than 9 hours.
- Do not contain the first four groups and at least one meaningful entry for *winds, turbulence,* or *sky coverage.*
- Are obviously repetitious in space, time, and elements.
- Are addressed to SAC or Air Force Global Weather Central (AFGWC) except at some overseas locations.
- Have already been transmitted while inflight (determine during postflight debriefing).

3-35. The next step in understanding COMBAR reports and their use is to identify each coded element. Refer to foldout 8 and follow along the symbolic form and plotting model as we discuss each group.

3-36. Foldout 8 on the left-hand side also shows a portion of AWS Form 81, COMBAR Code Form, on which the pilot records the information. Encoding of these reports is a relatively easy task for the pilot using this form, and the AWS Form 81 follows the same pattern as the symbolic form for your checking and encoding for transmission.

3-37. *Latitude and longitude* ($L_aL_aL_aL_aL_d$ $L_oL_oL_oL_oL_d$). The first two digits report latitude in degrees and the third and fourth digits report the latitude to the nearest minute. The fifth digit (L_d) reports the direction of latitude—N for north and S for south. Since 60 minutes is 1°, it is an easy matter to locate the aircraft position. For example, a location of 34°31' north and 119°46' west is "3431N 11946W" in the coded report. Notice that the longitude is also reported in degrees and minutes. L_d in the longitude group uses W for west longitude and E for east longitude.

3-38. *Time and flight level (GGgghhh).* A standard four-digit time group is sent in GMT but the "Z" designator is omitted. The flight level is coded in hundred of feet MSL. For example, a flight level of 16,000 feet is "160."

3-39. *True air temperature* (T_pTT). Each temperature report is prefixed by a letter "M" or "P," which denotes temperatures below or above freezing. The temperature is reported with two digits in degrees Celsius. When the temperature is missing, "///" is sent.

3-40. *Wind* (d_xddd/fff). The identifier prefixing the wind direction (d_x) tells the forecaster the navigational method used to determine data as follows:

Code Letter	*Navigational Method*
A	Doppler or Radar
B	Fix-to-fix using visual, radar, celestial, or Loran
C	Other

The wind direction (ddd) is in true degrees, and the speed is in knots (fff). If the wind data is missing, a solidius is coded for "d_x" followed by a space and seven solidi for ddd/fff.

3-41. *Height (jHHHH).* This group is used by the forecaster to determine pressure values in the upper atmosphere. The first value, "j," is coded either "M" or "P" to indicate a minus or plus height correction. The height data (HHHH), which is referred to as a D-value, is reported to the nearest 10 feet. That is, a D-value of 158 feet is encoded as "P0160." To be able to answer questions on this value and to insure that each observer is plotting D-values correctly, you should know that D-values represent the approximate height difference between the standard height and the actual height of the isobaric surface. For example, a D-value of "P0350" at the 300-mb level indicates that the height of the 300-mb level is approximately 350 feet higher than the standard heights of the 300-mb level.

3-42. *Turbulence (BBBbbb).* Turbulence data consists of two parts—intensity (BBB) and frequency (bbb). Since the code is computer handled, the turbulence group is encoded as a three-letter group (BBB), as a six-letter group (BBBbbb), or if missing, as MISG. The breakdowns for the intensity and frequency categories are:

Intensity	*Frequency*
NIL	None
LGT	Light
MDT	Moderate
SVR	Severe
EXR	Extreme
OCL	Occasional
INT	Intermittent
CUS	Continuous

3-43. *Visibility (VVVV).* Visibility is reported in nautical miles (nm) and represents horizontal visibility at flight level. It is reported according to the following breakdown:

GOOD – Over 3 nm
FAIR – 1–3 nm
Poor – Below 1 nm
MSG – Missing

3-44. *Sky cover ($N_1N_2N_3$).* Letter designators are used to report sky cover in COMBAR code. N_1 is the sky cover symbol for the layer below flight level; N_2 for layer at flight level; and N_3 for layer above flight level. These designators are:

C — Clear
S — Scattered
B — Broken
V — Overcast
U — Unknown or missing

If three layers are observed—scattered, broken, and broken—the sky cover code is "SBB" in the report. Bases and tops of layers are reported when available; however, they are reported along with plain language data.

3-45. *Refueling data (RRRR).* This entry pertains to inflight refueling operations and is based upon weather, such as poor visibility and turbulence, which might hinder refueling. The conditions for refueling are either "GOOD," "FAIR," "POOR," or "MISG."

3-46. *Contrails (IIII).* Condensation trails, or contrails as they are called, are elongated, tubular-shaped clouds composed of water droplets or ice crystals which form behind an aircraft. They form when the water vapor in the exhaust gas mixes with and saturates the air in the wake of the aircraft. When contrails are observed, they are reported "PRST" (persistent), "NPRS" (nonpersistent), "NONE," or "MISG."

3-47. *Aircraft heading ($A_cA_cA_c$).* This entry is reported in degrees and is reported only when clear air turbulence is reported. If it is missing or there is none, and remarks of some type follow, the aircraft heading is coded as three solidi (///). If no remarks follow this entry, and no heading is reported, the three solidi are omitted.

3-48. *Plain language remarks.* This section includes remarks that pertain to icing, thunderstorms, tops and bases of clouds, and unusual or hazardous flight conditions. Cloud heights are sent in separate groups, with the bases coded first, followed by the designator, and then the tops. If two layers are present—one layer scattered with bases at 1600, tops 3500 feet and the other is overcast at 8000, with tops at 11,000 feet—the coded report is "16S35 80V110." Each COMBAR report is coded as AWS Form 81, COMBAR Code, using the guidelines discussed in the preceding paragraphs. Normally COMBAR reports are not plotted at most detachments; however, some units require the plotting of these aircraft reports on upper air charts.

3-49. **COMBAR Code (Plotting).** Again, your role in connection with plotting COMBAR reports when required is to plot them accurately, neatly, and timely. Foldout 8 shows the most common method of plotting COMBAR reports. In addition to RECCO and COMBAR there is another aircraft code, AIREP, which is closely related to the coding format used in COMBAR. It is explained in the following discussion.

3-50. **AIREP Code.** AIREP code is a numerical code form that is prepared by inflight civilian and military transport aircraft. Military aircraft record each observation on MAC Form 193, Abbreviated Position and Weather Report, and transmit these reports to ground stations for dissemination by teletype.

In some cases, the pilot reports his observation(s) at the time of his debriefing. In either case, the reports are edited and transmitted via teletype to interested agencies.

3-51. The format for entries on MAC Form 193 is arranged by block entry for computer acceptability. The elements are broadcast from aircraft to ground stations in the order encoded on the Form 193. These broadcast elements and an example of encoded data follow:

	Element	*Encoded Data*	
	Aircraft number	76220	
Current Position Data	Latitude, degrees and minutes	4949N	
	Longitude, degrees and minutes	03000W	
	Time, GMT	0204Z	
	Flight level, hundreds of feet	370	
Next Position Information	Latitude, degrees and minutes	5045N	Not Transmitted
	Longitude, degrees and minutes	02045W	
	ETA	0249Z	
	Endurance, hours and minutes	0407	
Midpoint	Wind at midpoint or average wind, Tens of true degrees (DDFFF)	31065	
	Midpoint, latitude, degrees only	50N	
	Midpoint, Longitude, degrees only	035W	
Current Position Weather Data	Temperature (PTT/MTT), degrees C	M55	
	Hazard, weather and flight condition code figures (HWF_c)	101	
	Wind at current position, tens of true degrees (DDFFF)	30069	

CODE TABLES

H	HAZARD CODE (If more than one, transmit the more hazardous)	W	WEATHER CODE	Fc	FLIGHT CONDITION CODE
0	None	0	Clear	0	Clear
1	Light Turb	1	Scattered Clouds	1	Above Clouds *(tops less than 10,000 ft)*
2	Moderate Turb	2	Broken Clouds	2	Above Clouds *(tops 10,000 to 18,000 ft)*
3	Severe Turb	3	Continuous Layers	3	Above Clouds *(tops over 18,000 ft)*
4	Extreme Turb	4	Lightning	4	Below Clouds *(bases less than 10,000 ft)*
5	Trace *(Icing)*	5	Drizzle	5	Below Clouds *(bases 10,000 to 18,000 ft)*
6	Light Icing	6	Continuous Rain	6	Below Clouds *(bases above 18,000 ft)*
7	Moderate Icing	7	Continuous Snow	7	Between broken or overcast layers
8	Heavy Icing	8	Rain or Snow Showers	8	In Clouds
9	Hail	9	Thunderstorms	9	In and Out of Clouds

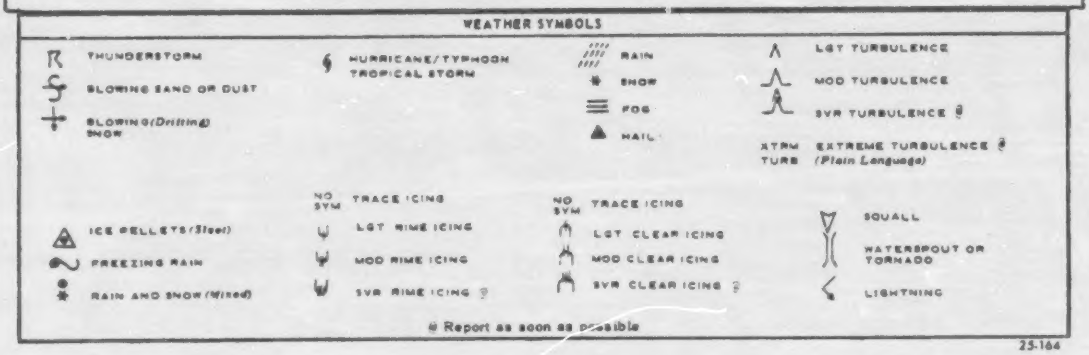
WEATHER SYMBOLS
THUNDERSTORM
BLOWING SAND OR DUST
BLOWING (Drifting) SNOW
HURRICANE/TYPHOON TROPICAL STORM
RAIN
SNOW
FOG
HAIL
LGT TURBULENCE
MOD TURBULENCE
SVR TURBULENCE @
XTRM TURB EXTREME TURBULENCE @ (Plain Language)
NO SYM TRACE ICING
LGT RIME ICING
MOD RIME ICING
SVR RIME ICING @
NO SYM TRACE ICING
LGT CLEAR ICING
MOD CLEAR ICING
SVR CLEAR ICING @
ICE PELLETS (Sleet)
FREEZING RAIN
RAIN AND SNOW (Mixed)
SQUALL
WATERSPOUT OR TORNADO
LIGHTNING
@ Report as soon as possible
25-164

Figure 6. Weather code table symbols and definitions.

3-52. All AIREP reports are edited to delete the Next Position Information before being relayed over teletype. Next Position Information is deleted because it contains nothing of meteorological significance. Referring to foldout 9, AIREP codes, you'll note that the Next Position Information (four groups) has been left out of the symbolic format for this reason.

3-53. **AIREP Code (Plotting).** AIREP code reports are generally plotted on constant pressure charts. If it is necessary to plot AIREP reports on weather charts at your unit, a letter or format for this purpose is displayed or outlined as shown in foldout 9, AIREP codes (MAC Form or ICAO Form). Figure 6 shows the code table definitions and weather symbols definitions, used on a MAC Form 193. AWSM 105–24, *Meteorological Codes*, also contains further information on all these aircraft codes if you need more information on how each item is derived.

3-54. A subject that is closely related to weather codes is the communications circuits used to relay all these codes on a nationwide basis. This subject is covered in the next chapter. Before proceding to that discussion, refer to your workbook and answer the chapter review exercise items for this section.

Weather Communications and Editing

WEATHER DATA observed or received during your shift on duty are needed for the planning of USAF operations. Weather not only affects flight operations, but also has a direct bearing on most military operations. Your weather observations need immediate dissemination to all local operating units so that decisions can be made concerning the weathers influence on their operations. In addition, your observations are relayed to all other regions that need the observations for carrying out their operations.

2. Both military and civil observations are given wide dissemination throughout the world. They are transmitted by teletype, radioteletype, and continuous-wave (CW) radio broadcast. This exchange of worldwide weather data supports not only military operations but also provides data for civil forecasting activities that are carried out by the various national governments.

3. This chapter discusses the various methods that are used to transmit weather data of all types. For example, if your assignment is at a weather relay center, you must be award of the editing functions that are essential to the orderly and efficient relay of weather data. If your assignment is at the detachment level, your primary concern is the transmission of your observations to the Automated Weather Network (AWN) relay center. Also you will study the responsibilities of the Air Force Communications Service (AFCS), the Air Weather Service (AWS), and the Modernized Weather Teletypewriter Communications System (MWTCS) in the exchange of weather data. The chapter also discusses facsimile networks, sateiliet networks, and the Astro/Geophysical Teletype Network. These are all part of the Weather Communications System.

4. Weather Communications Systems

4-1. Long-line dissemination of weather data between military weather stations is done by an automatic collection-dissemination system, which is operated by weather editors and AFCS personnel. At most AWS assignments, your duties include handling and transmitting weather data. These tasks contribute to the global interchange of weather data and are essential to the operational effectiveness of your unit. As an observer who gathers the data and prepares it for transmission, you are the key man in this interchange of weather data. To fully understand your role in the dissemination of weather data, you must know about the various networks and their operation.

4-2. **The USAF/DCS Weather Communications Networks.** These are the weather teletype networks which include the Automated Weather Network (AWN), weather facsimile network, and the global weather intercept and broadcast networks. They provide the facilities for rapid interchange of weather data on a worldwide basis and are discussed individually in this section.

4-3. The mission of the USAF/DCS Weather Communications Netwoek is to provide communications service to the Department of Defense (DOD) agencies and the Air Weather Service in support of global missions. Weather data, because of its unique composition and the volumes of information which must have wide and timely dissemination, requires special communications networks and message handling procedures. The USAF/DCS Weather Communications Networks and AWN provide this unique service.

4-4. To make this service operate smoothly, all AWS personnel operating weather communications facilities must follow the procedures and operating schedules contained in AWSM 105-2, Volume I, and AFCSR 105-2 series publications (especially Volume I and II of the latter). AFCS publishes detailed communications operating instructions in AFCSR 105-2, Volume I. Operating schedules, detailed instructions, and supplementary procedures are issued by the responsible AFCS echelons. AWS publishes a master weather message catalog (AWSM 105-2, Volume II) containing complete descriptions of all weather messages available within the USAF weather communications system. These publications govern the military contribution to the overall interchange of weather data. We have used them to develop the following explanation of the present military communications concepts and circuitry.

4-5. **Air Weather Service (AWS) Teletype Systems.** For brevity, these communications systems are referred to as COMET I and COMET II (A and B) (Conus Meteorological Teletype System). These two circuits make up the ADCAD-OWS Weather System (Airways Data Collection and Dissemination, and Operational Weather Support System). COMET I and II consists basically of three parallel, eight-circuit teletype networks. They operate at 100 words per minute and radiate from Tinker Weather Relay Center (KWRF), Tinker AFB, Oklahoma, to various tributary stations and receive only terminations within the continental Unit States (CONUS). An additional circuit, COMET III, is discussed in paragraphs 4-11 and 4-12.

4-6. The COMET system establishes a method of collecting and disseminating weather data for military weather reporting stations within the United States. The ADCAD/OWS programmer is the key to the operation of COMET I and II weather circuits. The programmer controls the switching and control functions of COMET I and COMET II circuits. To better understand how the ADCAD/OWS programmer affects the military communications system, let's examine the operation of COMET I first.

4-7. *COMET I.* COMET I can be described as the U.S. circuit that is controlled by the ADCAD programmer to collect and disseminate airways data. To you, COMET I provides a method of long-line dissemination of your observations from the ROS. At the start of each hour, the ADCAD programmer will already have automatically activated the necessary functions to clear COMET I for the hourly collection of airways data. In addition to this hourly polling of ADCAD reporting stations, the ADCAD programmer also provides for a continuous scan of special observations.

4-8. The COMET I receive-only capabilities are usually located in the forecaster section of the weather station. This source of the latest airways data enables the forecaster to keep abreast of weather conditions and provides a readily available source of observations for briefing pilots over the PFSV.

4-9. *COMET II.* The COMET II circuit is the Operational Weather Support (OWS) system. This circuit serves two distinct purposes and is, therefore, referred to as COMET II A and COMET II B. At present, when the ADCAD/OWS programmer engages the COMET I circuit for polling of hourly airways reports (H-Time), the programmer also interconnects circuit COMET II B. During this interconnection period all OWS installations on COMET II B circuit receive hourly airways weather data only. Immediately following the completion of ADCAD polling on COMET I, COMET II is released from this interconnection period and becomes an independent broadcast network that is primarily for the dissemination of data that is collected on COMET II A.

4-10. In terms of your job, COMET II provides a means for receiving *operational support data* at your station. This includes PIREPs, RAREPs, and TAF reports. To understand the differences between COMETs II A and II B, you need to know that COMET II A is the circuit and *collects* operational data, and that COMET II B is an independent circuit that *disseminates* the collected data. COMET I is used solely for the *collection* of all *airways* weather data. Finally, you need to recall that the ADCAD/OWS programmer controls both COMET I and COMET II. The programmer does all the switching and control necessary to achieve maximum circuit utilization and the orderly exchange of weather data.

4-11. *COMET III.* The third military communications circuit, COMET III, operates at 375 words per minute. This network is a multipoint circuit consisting of eight receive only circuits terminating at various CONUS facilities. COMET III originates from Carswell Automatic Digital Weather Switch (ADWS), Automated Weather Network (KAWN) located at Carswell AFB, Texas.

4-12. In terms of your job, COMET III provides a means for receiving operational support data, similar to COMET II. Some of these items are forecasts, upper air data, synoptic data, and numerous other items of information.

4-13. Military weather communications are a large part of your workload while you are on duty at the weather station. You are continually filing and posting the incoming weather messages in their correct place. The longer you are associated with weather communications, the better versed you become. Your knowledge of the basic communications tasks will help you to move on to advanced communication procedures as you continue to mature as a weather observer. In addition to the military weather communications you have just studied, there are some things you should know about the National Weather Service (NWS) communications system.

4-14. **National Weather Service (NWS) Teletype Systems.** The Federal Aviation Administration (FAA) controls the National Weather Service Communication System. The major differences between military and FAA communications systems are those that are necessary so that each can meet the needs of its respective using agencies. Both weather services (AWS &NWS) obtain the fullest use of data received by means of teletype circuits. At a weather detachment in the midwest, your station may be the only military weather station for 200 or 300 miles. When this is the case, the forecaster uses the surrounding NWS stations for the weather data that he needs.

4-15. Your station duties in relation to the FAA weather communications are not as complicated as those that involve your military responsibilities. Your main task is to receive the incoming bulletins from FAA circuits and to file them. This is a task that requires some knowledge on your part of the operation of each FAA circuit at your station.

4-16. The Modernized Weather Teletypewriter Communications System (MWTCS) consolidates the circuit control and relay functions of FAA communications circuits—Services A, C, and O—into a single Weather Message Switching Center (WMSC) at Kansas City, Missouri. These functions are performed automatically by a group of electronic computers which are combined to operate as a communications switch. All Service A and C circuits extend directly into the WMSC. Certain portions of the Service O circuits also extend directly into the computer switch. While others, from overseas points, pass through the Aeronautical Fixed Telecommunications switch which is collocated and interconnected with the WMSC. Computer-to-computer links provide for exchange of data between WMSC and the National Meteorological Center at Suitland, Maryland, and between the WMSC and the USAF Automated Network at Carswell AFB, Texas. Of the three major FAA weather communications circuits (Services A, C, and O), Service A is the most widely used in your job.

4-17. *Service A.* Service A consists of weather circuits that are numbered 8001 through 80040. These weather circuits provide all stations on the circuit with the desired coverage of airways data. Also Service A transmits operational support data such as PIREPS and RAREPS. This is done in a manner similar to the ADCAD programmer of COMET I. The airways data is collected each hour on the hour and is routed to all circuits; each individual circuit receives data for its immediate area first.

4-18. *Service C.* Service C is another weather communications circuit that is used at NWS stations. It performs a similar service as COMET III does for the military stations. Service C provides the additional data necessary at weather stations, such as upper wind information, synoptic data, and various other supplemental weather data. The important thing to remember about FAA weather communication circuits is that each circuit is governed by an FAA publication which describes in detail the operation of that circuit. In contrast to the relatively stable operation of the teletype circuits, dramatic changes have been made in the relay of weather data. The reason for these changes are, of course, the increased capability of the Automated Weather Network (AWN).

4-19. **Automated Weather Network (AWN).** Although most weather observer personnel understand the basic operations of the automated Weather Network, few observers realize the significance of their duties in relationship to the operation of AWN. Each weather message transmitted from your station is processed into the AWN for further dissemination. The quality of these transmissions, therefore, determines the success of the AWN. For this reason, you must be familiar with local communications policies and understand the AWN operations.

4-20. *Network composition.* The Automated Weather Network (AWN) is comprised of real-time computers which are located in major geographical areas and are linked by high-speed data circuits. Terminated in the computers at each of the Automatic Digital Weather Switches (ADWSs) are low-speed circuits from which the weather data are received and distributed for that geographical area. Data thus collected are automatically edited and distributed in accordance with requirements.

4-21. Currently, there are four ADWSs servicing five high-speed data users:

a. The four Automatic Digital Weather Switches:

- Carswell AFB, Texas.
- Fuchu AS, Japan.
- Croughton AS, England.
- Clark AB, Philippines.

b. The Five high-speed subscribers:

- Air Force Global Weather Central (AFGWC), Offutt AFB, Nebraska.
- Air Force Asia Weather Central (AWC), Fuchu AS, Japan.
- Air Force European Weather Central (EWC), Croughton AS, England.
- National Meteorological Center (NMC), National Oceanic and Atmospheric Administration (NDAA), Weather Bureau, Suitland, Maryland.

- Fleet Numerical Weather Facility (FNWF). US Navy, Monterey, California.

4-22. Figure 7 shows the Automated Weather Network System. Notice that the "hub" of AWN is the Automatic Digital Weather Switching (ADWS) center at Carswell AFB, Texas. Figure 7 also shows the rate at which weather data is relayed between the various AWN centers. As shown, presently, weather data can be relayed over AWN circuitry at rates as high as 4800 WPM (3600 BAUDs). The term "BAUD" is a computer term used to express the rate at which weather data is relayed over computerized circuits. More precisely, *one* BAUD *equals one-half dot cycle per second in Morse code.*

4-23. *System relationship.* The various weather networks, including AWN and facilities of the USAF, comprise a system for collecting and editing data, delivery of data to weather centrals and forecast facilities, and distribution of generated products to user activities. Automation of the system will be evolutionary through upgrade and expansion of AWN facilities and program development to allow integration of the manual networks and facilities into the automated facilities comprising the AWN. As automation progresses, the AWN will become the system as an entity. The next teletype network we are going to discuss briefly is the Astro/Geophysical Network (ATN).

4-24. **Astro/Geophysical Teletype Network (ATN).** This is a solar observing and forecasting network originating from Carswell Automatic Digital Weather Switch (ADWS) at Carswell AFB, Texas. The AWS Space Environment Support System (SESS) is handled by this network.

4-25. The AWS Space Environmental Support System (SESS) is a worldwide network of solar optical, radio and ionspheric observing

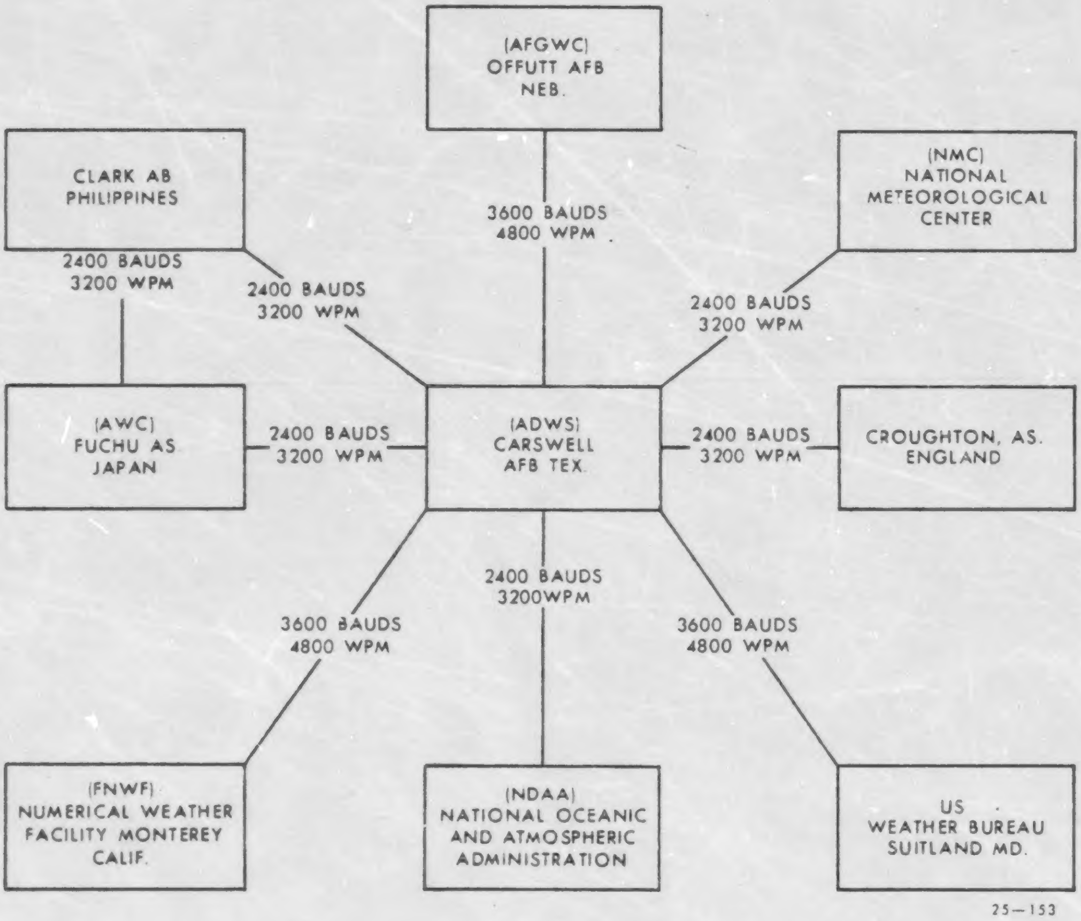
(AFGWC)
OFFUTT AFB
NEB.
CLARK AB
PHILIPPINES
(NMC)
NATIONAL
METEOROLOGICAL
CENTER
3600 BAUDS
4800 WPM
2400 BAUDS
3200 WPM
2400 BAUDS
3200 WPM
2400 BAUDS
3200 WPM
(AWC)
FUCHU AS
JAPAN
2400 BAUDS
3200 WPM
(ADWS)
CARSWELL
AFB TEX.
2400 BAUDS
3200 WPM
CROUGHTON, AS.
ENGLAND
2400 BAUDS
3200WPM
3600 BAUDS
4800 WPM
3600 BAUDS
4800 WPM
(FNWF)
NUMERICAL WEATHER
FACILITY MONTEREY
CALIF.
(NDAA)
NATIONAL OCEANIC
AND ATMOSPHERIC
ADMINISTRATION
US
WEATHER BUREAU
SUITLAND MD.
25—153

Figure 7. Automated Weather Network

and forecasting sites located at both civilian and military observatories. These sites exist for the expressed purpose of providing both routine and special (near real-time) astrogeophysical observations and forecasts to a central collection agency—the Aerospace Environmental Support Center, NORAD, Cheyenne Mountain Complex, Colorado. The Aerospace Environmental Support Center (AESC) analyzes the incoming data and provides forecasts, alerts, and warnings to various DOD and non-DOD customers. In addition to the weather teletype networks, you should be aware of the weather facsimile networks and their operation

4-26. **Weather Facsimile Communications.** The USAF/DCS Weather Facsimile Communications Global System is comprised of networks which serve all DOD requirements and interface with the National Weather Service (NWS) network and Federal Aviation Administration (FAA) networks. Facsimile products, by their uniqueness in composition, handling procedures, acquisition of data and grading criteria, require special communications networks. The basic objective of a facsimile system is to transfer information quickly, accurately, and reliably.

4-27. **Facsimile Theory.** A picture can be transmitted over electrical paths by dividing the image into extremely small square elements, noting each element's degree of blackness or whiteness and transmitting this information for reconstruction at the distant end. In analog systems, control signals from the transmitter synchronize the receiver coordinate system during the transfer of continuous element information for reconstruction. A typical facsimile image 18 inches x 18 inches requires transmitting as many as 3,000,000 square elements of black or white information. It is important to note that electrical facsimile transmission is an approximation of an image and is not to be considered an exact copy.

4-28. **System Composition.** The weather facsimile networks are primarily composed of the strategic facsimile network and the national facsimile network within the CONUS, and the European and Pacific facsimile networks overseas. These systems operate at 60, 120, and 240 scans per minute (SPM), depending on the network capability, and employ both point-to-point and omnidirectional radio broadcast techniques as the situation warrants. Circuits which comprise the CONUS facsimile networks will now be discussed. The first network we are going to discuss briefly is the national facsimile network (WFX1234).

4-29. *National facsimile network (WFX1234).* The national facsimile network is the basic weather graphics network. It serves approximately 250 NWS offices, 320 military and other government units, and nearly 350 extension service (nongovernment) users—more than 900 "drops" in all.

4-30. Except for radar summary charts and digitized mosaics from National Environmental Satellite Center (NESC) all material originates at the National Meteorological Center (NMC). The network extends throughout the United States with connections in Canada at Vancouver and Montreal. The charts are relayed to Alaska over military channels from West Sweetgrass, Montana. In Alaska, selected charts are put on the intra-Alaskan circuit. Selected charts are also relayed to Honolulu, HI. The second network we are going to discuss in the forecast office facsimile system (FOFAX GF 10206, 7, 8).

4-31. *Forecast office facsimile system (FOFAX GF 10206, 7, 8).* This network is often referred to as the satellite network. FOFAX serves forecast offices and military weather stations by providing satellite material and other meteorological data needed in their preparation of forecasts and weather warnings.

4-32. The network also distributes NESC digitally prepared mosaics from ESSA satellites and APT data acquired by NESC (Wallops Island, WBFO San Francisco, Calif.) and AF Kunia, HI. The third facsimile network we are going to discuss briefly is the strategic facsimile network (AFX109).

4-33. *Strategic facsimile network (AFX109).* This is an allocated full-period 120 SPM, half-duplex multipoint military facsimile network terminating at various CONUS facilities including Alaska. The transmitting stations on this network are as follows:

- Offutt Weather Relay Center (KOFF).
- Suitland Weather Relay Center (KWAF).
- Langley Forecast Center (KLFC).
- Charleston Forecast Center (KCHS).

Offutt is designated as the network central station on this circuit.

4-34. This facsimile network provides services to the user on the basis of operational needs. Naturally, the number of facsimile charts required by a detachment supporting a major SAC operation is different from that required to support an ATC operation.

4-35. Each AWS activity that has a facsimile circuit maintains a program for evaluating and recording the quality of the weather maps received. This quality control program enables you to determine the status of the facsimile legibility at a glance. Poor quality reception is thus documented and can be used to obtain improved maintenance or better equipment. AWS personnel grade weather facsimile products into three categories:

Grade 3: An excellent product. The chart has been recorded in phase and all typewritten information of pica type or larger is clearly legible. Hand printed information is of uppercase pica type size or larger.

Grade 2: A good chart, of lesser quality than Grade 3, but one which meets the minimum acceptable standard of legibility illustrated in AWS Manual 105–2, Volume I, Attachment 4. The chart may be out of phase and graded "2," provided *not more* than *10 percent* of the chart is lost.

Grade 1: A chart that does not meet AWS minimum acceptable standards of legibility.

4-36. In addition to the weather chart grading system, your unit (if on the FOFAX network) is required to maintain a program of evaluating the products received from the satellite cameras. The definition of the picture quality is as follows:

Good—(Excellent to Good Product) defined in quality as recording with 30 percent or less imprefections and 90 percent or more of the information available in the data.

Acceptable—(Fair to Poor Product) defined in quality as a product with 30–50 percent imperfections and 50–90 percent of the information available in the data.

Unacceptable—(Not Usable) defined as a recording qith greater than 50 percent imperfections and less than 50 percent of the original data available in the product.

4-37. Most stations have a standard facsimile grading form near the facsimile recorder for an observer to grade the incoming charts. In addition to this evaluation of chart quality, at many stations observers are encouraged to color certain facsimile charts before they are posted. Most observers find this work enjoyable because it gives them a chance to apply their knowledge of meteorology.

4-38. Weather communications functions at stateside stations are generally standard throughout AWS units. Most of the communications policies are standard and the equipment types are similar. This is *not* necessarily the case when it comes to weather data requirements, so let's see what weather data requirements are and how they are established.

5. Weather Data Requirements

5-1. Weather data requirements are lists of data that weather units need to carry out their missions. These requirements fall into *four major categories.*

a. Meteorological data routinely available in the worldwide weather communications complex. The sources of these data are described in the various military and civil (U.S. and foreign) communications publications.

b. Meteorological products prepared by centrals/centers that do not fall in the category described above.

c. Meteorological data and products specifically tailored to support military command/control systems.

d. Meteorological packages containing weather information designed for use in supporting contingency operations.

Occasionally unique situations arise that require a weather unit to submit a *permanent* or *temporary* request for weather data not listed on its weather data requirements. The data requirements system has the flexibility to meet such occasions. However, when the situation permits, normal procedures must be used.

5-2. AWS units are responsible for establishing and registering their weather data requirements (through command channels) with the appropriate AWS theater agency. So that the weather communications system can provide the required meteorological data to AWS units at the time the data are needed, three categories of priority have been established. Individual units and parent headquarters evaluate each weather data requirement submitted to insure that it is placed in its proper category; otherwise the weather communications system will be overburdened and its responsiveness impaired. The three categories of priority under which data requirements can be submitted are *routine, urgent,* and *immediate.*

5-3. **Routine.** A routine request is one necessary to meet normal mission changes. It must fall within the geographical confines of the area of forecast responsibility and be routinely used in carrying out the unit mission. Forward requests for data in this category through channels on AWS Form 23, MANAM (Manual Amendment) Action Request. You will find instructions for preparing the request printed on the front of the form. When you prepare the request, you furnish the following information to the AWS MANAM agency.

a. Specification of the data type(s) required; e.g., hourlies, TAFs.

b. WMO block/station number or ICAO/FAA call sign of required station(s) as appropriate.

c. The message heading and date-time-group of bulletins which cannot be identified by precise station content; e.g., weather warnings, AIREPs.

d. Detailed justification which supports the data requirement request.

e. Date the service is requested to begin. (Delivery of data identified as routine does not begin before 15 days after the AWS MANAM agency receives the request. Do not ask weather editing units directly for routine support for they are not allowed to support such requests.)

f. Duration of the requirement. Indicate whether the requirement is permanent or temporary. Don't use the term "until further notice"; it will not be accepted without a detailed explanation.

g. The frequency the data are required; i.e., Monday through Friday or 0000Z and 1200Z Monday through Friday.

5-4. **Urgent.** A request can be classed as *urgent* if your unit receives a requirement for data and wasn't notified soon enough to submit the requirement as routine. An example is a requirement generated by a "no notice exercise" or other unusual circumstance. Under urgent conditions, the AWS unit is authorized to ask AWS weather editing units directly by priority message for support, and weather editing units must, to the best of their ability, support these requests for a 10-day period. Urgent requests must contain the information listed in paragraph 5-3 (*a* through *g*). In addition, within 24 hours, your unit must furnish the appropriate AWS theater MANAM agency with:

a. The date direct support from the AWS weather editing unit was requested.

b. All information listed in paragraph 5-3.

c. A brief statement explaining the urgent requirement or the exercise code name, as applicable. If the duration of the requested support is for 24 hours or less, detachments are exempt from *a*, *b*, and *c* above.

5-5. **Immediate (Tactical Systems).** Data support required to meet a *tactical action* or situation gravely affecting the *national security* falls in the *immediate* category. The AWS unit concerned is authorized to request AWS weather editing units directly by immediate message, for support under immediate conditions. Weather editing units must support these requests for an unlimited period. AWS units requesting support under these conditions must immediately furnish the appropriate AWS MANAM agency, by message, the information contained in paragraph 5-3, *a* through *g*.

5-6. Requests for direct support under urgent or immediate conditions are transmitted as follows:

a. Urgent. Transmit urgent requests by one of the following means in the order listed: weather circuits, common user (AUTODIN) or telephone. You must confirm telephone requests by message via the weather circuits. The message should be given the same priority as the original request.

b. Immediate. Use the most expeditious means available.

5-7. **Annual Validation of Standard Weather Data.** In addition to obtaining data based on the requirements of a particular mission, you must validate your everyday requirements. This is done by an annual validation. AWS theater MANAM agancies are responsible for the overall management of the data requirements program within their respective areas of interest. The validation procedure insures that individual unit data requirements are registered with the appropriate MANAM agency and maintained in a current status. The procedure works as explained in the following paragraphs.

5-8. Annually, prior to 15 January, the appropriate AWS MANAM agency forwards copies of the previously registered individual unit data requirements list to their immediate subordinate headquarters (wings, groups, or squadrons). Sufficient copies are provided to enable each activity to retain one copy and return two copies to the AWS MANAM agency after certification.

5-9. After your unit receives copies of its registered data requirements list, your unit reviews the list for currency and accuracy. If no changes or corrections are necessary your unit retains one copy of the data requirements listing for record purposes and forwards the other copies through channels to the AWS MANAM agency.

5-10. If deletions or corrections to the data requirements list are required, your unit indicates all deletions by lining out the message heading entry on the data requirements listings. If there are corrections, these are indicated by making necessary changes to the erroneous bulletin entries. Then your unit forwards the list through channels, keeping one copy for its records.

5-11. In Section 4 we covered teletype and facsimile circuits, and in Section 5 we told you how you obtain the data; but what about the weather messages themselves? How are the manuals governing the circuits maintained? How are the messages prepared? What are the procedures for evaluating this data? These and other questions are answered in the paragraphs that follow in Section 6. Before proceeding to Section 6, turn to your workbook and answer the chapter review exercises for Sections 4 and 5.

6. Communications Manuals and Procedures

6-1. *Types of Communications Manuals and Regulations.* AWS communications manuals provide guidance on data requirements, weather message descriptions, weather editing, communications changes and revisions, evaluation and communications effectiveness, maintenance and supply, and related subjects. AWS communications manual 105-2 is divided into six volumes. Volume I applies to all AWS units, regardless of location.

TABLE 13
DATA DESIGNATORS

Surface Data	
SA	AERO/METAR hourly & half-hourly
SD	Radar reports
SE	Seismograph reports
SF	SFAZI/SFLOC/SFAZU
SG	Micro seismograph reports
SH	SHIP/SHRED
SI	SYNOP/SHIP intermediate hours
SM	SYNOP/SHIP main hours
SN	SYNOP/SHIP nonstandard hours
SP	MMMMM/BBBBB/SPESH/SPECI
SR	River and special service reports
SW	Supplementary airways weather reports
SX	Miscellaneous
Upper - Air Data	
UA	AIREP
UB	ABTOP
UC	Combined pilot-balloon and rawin report
UD	Maximum wind
UE	TEMP/TEMP SHIP (Part D)
UF	TEMP/TEMP SHIP (Parts C and D)
UG	PILOT/PILOT SHIP (Part B)
UH	PILOT/PILOT SHIP (Part C)
UI	PILOT/PILOT SHIP (Parts A and B)
UJ	Combined TEMP (Parts A and B) and PILOT (Parts A and B)
UJ1	Combined TEMP PILOT (Parts C and D)
UJ2	Combined TEMP (Complete) from Computer Processed Raw Data
UK	TEMP/TEMP SHIP (Part B)
UL	TEMP/TEMP SHIP (Part C)
UM	TEMP/TEMP SHIP (Parts A and B)
UN	Rocketsonde
UO	Tropopause
UP	PILOT/PILOT SHIP (Part A)
UQ	PILOT/PILOT SHIP (Part D)
UR	RECCO
US	TEMP/TEMP SHIP (Part A)
UT	CODAR
UV	Vector wind differences
UW	RAWIN
UX	Miscellaneous

6-2. *AWSM 105-2, Volume I.* This manual deals with the communications policies and responsibilities of AWS units. As an observer you need to be familiar with weather message description and content. This volume provides some of this information. For example, you can use this volume to break down the message heading of any weather collection transmitted over AFCS circuits. Symbolically, every weather message has a heading of "TTAA(i)C-CCC(K)YYGGgg."

6-3. The first two letters, "TT," refer to the type of data. Table 13 is a partial listing of data designators which identify the type of weather data for any message. For example a "TT" of SI identifies surface synoptic (land or ship) data for intermediate hours. "FT" indicates terminal forecast data.

TABLE 14
GEOGRAPHICAL DESIGNATORS

AA	Antarctica
AB	Albania
AC	Arctic Region
AD	Aden
AF	Africa
AG	Argentina
AI	Ascension Island
AJ	Austral Islands
AK	Alaska
AL	Algeria
*AM	Mid-Atlantic
AN	Angola
AO	West Africa
AR	Arabian Sea
AS	Asia
AT	Antigua
AU	Australia
AZ	Azores
BA	Bahamas
BB	Bay of Bengal
BC	Bechuanaland
BD	Basutoland
BE	Bermuda
BG	British Guiana
BH	British Honduras
BK	Banks Island
BM	Burma
BN	Bonaire
BO	Bolivia
BQ	Baltic Sea Area
BR	Bardados
BS	Bering Sea
BU	Bulgaria
BX	Belgium, Luxembourg
BY	Byelorussian S. S. R.
CA	Caribbean
CB	Congo (Leopoldville)
CC	Curacao
CE	Central African Republic
CF	Congo (Brazzaville)
CH	Chile
CI	China
CL	Ceylon
CM	Cayman Islands
CN	Canada
CO	Columbia
CR	Canary Islands
CS	Costa Rica

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* Only approved for USAF use.

6-4. Symbolically, the next two digits of a weather message heading (AA) refer to the geographical location of the message. You are not expected to know each geographical designator, but you should be able to recognize some of the designators for countries that play an important role in the worldwide exchange of weather data. Table 14 shows a partial listing of the geographical designators. Familiarize yourself with the designators used by your station.

6-5. Some weather message headings contain a number following the data and geographical designators. This number is included with the message heading for at least three different reasons.

- To distinguish between two or more messages of similar content from the same geographical area. (First message, no number; second message, 1; third message, 3; etc.)
- To indicate the height level and sections of analysis or prognostic facsimile charts (3 for 300 mb, 5 for 500 mb).
- To indicate height levels, periods of validity, and sections of upper air prognosis

messages (1 = 12 hours, 2 = 24 hours; in increments of 12 hours).

6-6. The next main part of the weather message heading is the location indicator of the station originating the message (CCCC). The important thing to remember about this group is that although the identifier is usually from the same geographical area that the message content is for, it does not necessarily have to be. For instance, a collection that is compiled for transmission in Japan contains the location identifier of the center in Japan that prepared the message, rather than the actual geographical source of the data. This location identifier is based on the International Civil Aviation Organization (ICAO) listing of communications centers. For example, the ICAO identifier for Hickam AFB, Hawaii, would be "KHIK." In some cases Department of Defense agencies, such as AWS, relay this data using circuit nomenclature in place of the standard ICAO identifier. This is because of the cross relay of weather data from other WMO sources.

6-7. The last part of the weather message heading provides the time data (YYGGgg). This group is always expressed with reference to Greenwich Mean Time (GMT). The time reported for each category of data is shown below.

- Observations—Scheduled time of the observation.
- Specials—Actual observation time.
- Analysis and prognoses—Time of the data used to derive analysis or prognosis.
- Corrected (COR) messages—Time of original message.
- Variable reports such as PIREPs or amended forecasts (AMD)—The time of message preparation.

6-8. AWSM 105–2, Volume I, also prescribes the procedures for the withdrawal of weather messages and the issuance of no content indicators (NCIs). Weather messages that have lost their operational value because of time decay should be withdrawn from the network. This task of withdrawing messages is usually restricted to AWS personnel working at a communications center; however, knowledge of withdrawal procedures will aid you if you have to explain why a certain bulletin was never transmitted. An example of some reasons that bulletins may be withdrawn are:

- Messages have been superseded by later data of the same content.
- Messages are outdated 24 hours or more and have not previously been withdrawn.

6-9. Requests for data that has previously been withdrawn are honored when:

- The requesting agency is a forecast center or central.
- The request is in the *urgent* or *immediate* category.

6-10. Any person who is responsible for preparing meteorological messages for transmission by the USAF weather communications network must issue the appropriate NCI when the message is unavailable at the appointed transmission time. AWS permits the use of only one NCI per message, and limits usage to one of the following types of NCIs:

NIL—Message available, but not ready for transmission. Requires NTD message to follow.

NODAT—Message is not available at the station of origin because of a malfunction of the originator's method of receiving the message. Requires the originator to take action through alternate sources to obtain this message.

NONE—Message not available for transmission based upon facts known by the originator.

PLAIN LANGUAGE—Authorized for use only when considered important to using agencies (e.g., COMPUTER MALFUNCTION, ESTIMATED DOWN TIME—5 HRS.)

This is only a sample of some NCIs. If you are assigned to a weather communications center, your involvement in issuing NCIs will be a routine task. Now we'll examine the contents of AWSM 105–2, Volume II.

6-11. *AWSM 105–2, Volume II.* Volume II contains a weather message category for weather messages and facsimile charts for the continental United States (CONUS), Caribbean, North Atlantic, Canada, Bermuda, Azores, South America, and adjacent waters. Because the same procedure of cataloging messages is used for each area of the world, you need only know the geographical boundaries of remaining AWSM volumes (IV, V, and VI).

Volume	*Area*
IV	Europe, Africa, Western Asia and USSR (to 90° E.), Near and Middle East and adjacent waters.
V	Alaska and Aleutian Islands and Adjacent waters.
VI	Pacific Ocean area, Australia, Eastern Asia, and USSR (to 90° E.).

6-12. Volume II contains a separate alphabetical listing of weather messages (teletype and computer) and facsimile messages. This means that each weather message heading can be located alphabetically. Volume II, although it has certain geographical boundaries, list any bulletin, regardless of location, that is relayed on any circuit listed in Volume II. The following is an example of a bulletin in AWSM 105–2, Vol. II.

```
UHJP RJTD                                  4GR 300                    607000401 /
  PART C OF PILOT/RAWIN REPORTS FROM JAPAN AND THE PACIFIC            607000501 /
47401 WAKKANAI  47624 MAEBASHI (1)     47807 FUJUOKA                  607000502
  412 SAPPORO     646 TATENO             827 KAGOSHIMA                607000503
  420 NEMURO      650 KAMEYAMA (1)       898 SHIMZU/ASHIZURI (1)      607000504
  582 AKITA       655 OMAEZAKI (1)       909 NAZE                     607000505
  590 SENDAI      678 HACHIJOJIMA        945 MINAMIOAGARIJIMA         607000506
  600 WAJIMA      744 YONAGO             684 YOKKAICHI (1)            607000507
  604 MIIGATA (1) 778 SHIONOMISAKI       4YT SHIP TANGO (2)           607000508
                  772 OSAKA              918 ISHIGAKIJIMA             607000509 /
DTG 0000Z PE6H   FT 0354Z PE6H                                        607000601
CODE FM 32C and FM 33C                                                607000701
REMARKS COMPILED BY THE JMA                                           60700801
     (1) AVBL 0000Z ONLY                                              607000802
     (2) AVBL DURING THE SUMMER SEASON ONLY                           60700803
```

This example shows the type of information provided on each message. The example (UJFP RJTD) lists all the necessary information concerning the message except for the actual transmission time, which is a responsibility of AFCS. The data "4GR 300" tells you that the collection is transmitted four times a day (4) and contains a group count as high as 300 groups (5-digit groups). The plain language data lists the type of data, beneath which each reporting station is listed. The date-time group (0000Z) is placed near the bottom of the collection and is followed by the frequency of transmission (plus each 6 hours). The file time (FT), 0354Z, is followed by the frequency, PE6H. The last elements of the message description show the type meteorological code used (FM 32C and 33C) and additional remarks. The numbers at the right-hand side of the message are used primarily by AFCS personnel who monitor the relay of weather data. As you can see from the example weather message, the message content is easy to interpret. Now that you have completed the study of AWS manuals, let's turn our attention to Air Force Communications Service Regulations (AFCSR) to see how they influence your job as an observer.

6-13. The responsibility of AFCS personnel who operate communications networks is to provide communications services for AWS in support of their global mission and other DOD agencies as required. Basicall, the responsibility of AFCS in weather communications is to publish and maintain detailed communications instructions and operating schedules.

6-14. *AFCSR 105–2, Volume I.* This regulation outlines general policies and instructions for the collection and distribution of weather message traffic throughout the weather communications network and associated facilities. Knowledge of these policies should give you the background information you need at a weather station. For example, if you are assigned at detachment level, AFCS personnel do not operate your communications facilities. For this reason you must understand the policies described in this manual.

6-15. To fully understand general operating procedures of the network, as outlined in Volume I, you should first recall the characteristics of the following types of circuits:

Multiplex Circuit—Capable of sending more than one message over one line or channel at the same time.

Duplex Circuit—Capable of sending and receiving, but not at the same time.

Half-Duplex Circuit—Capable of sending and receiving, but not at the same time.

Point-to-Point Circuit—Between two fixed points.

Multipoint Circuit—Circuit shared by two or more stations.

6-16. Net control stations (NCSs) are assigned for all point-to-point and multipoint full-period weather circuits. The NCS responsibilities are listed below.

- Enforce circuit discipline.
- Insure that other stations in the network comply with established communications procedures.
- Release circuits to long-line and maintenance agencies for circuit lineup.
- Conduct scheduled sequence collective and scheduled SCANs.

In keeping with these responsibilities, the net control stations communicate directly with each station when they detect operational troubles. Your concern in this area, of course, is to maintain good circuit discipline and to insure that you are familiar with the proper actions to take if you are contacted by the NCS station.

6-17. Because the primary responsibility of net control stations is to keep the network operating smoothly, network personnel do not have the time to detect every minor discrepancy that is made by reporting stations. For this reason a monitor station is assigned for each multipoint collective, radio teletype broadcast, and facsimile circuit. The monitor station insures that circuits are operated in accordance with prescribed procedures and schedules. The monitor station formally reports discrepancies through administrative channels to the operating agency for review and corrective action.

6-18. Monitor stations do most of their evaluation after they receive either hard copy, type, or both, for each circuit. Experienced personnel check these roles for discrepancies. They summarize these discrepancies bi-weekly or weekly and forward them to the agencies concerned. They usually forward discrepancies for reasons listed below.

a. Missing from sequence collectives without valid reason.

b. Noncompliance with circuit schedules.

c. Transmission of garbled traffic.

d. Incorrect preparation of weather and associated traffic for transmission.

e. Unnecessary consumption of circuit time.

f. Transmission of unauthorized data.

g. Failure to honor ZEE requests (request the following message be transmitted).

h. All other violations of established procedures.

6-19. Volume I of AFCSR 105−2 also lists those agencies required to submit communications operations reports. The intent of these communications reports is to identify areas of substandard performance; to continually evaluate data related to objectives, standards, and capabilities of all activities concerned; to establish corrective measures or recommendations for each level of operational control; and lastly, to make interpretative comments on current or anticipated effects on a station or network basis. Weather relay stations are responsible for preparing detailed reports which provide sufficient data to analyze each phase of their operation. Since these reports are usually prepared by AFCS personnel, you need only to examine the data reported by the net control station. Net control stations prepare a monthly report containing the following information.

a. Percentage of time the circuit is available (operational). Circuits falling below 95 percent efficiency require a detailed explanation of the cause.

b. Total number of scheduled messages required.

c. Total number of messages transmitted.

d. Percentage of scheduled transmissions made on time.

e. Percentage of scheduled transmissions made late and nontransmission by cause (line trouble, local trouble, etc.).

f. Total number of nonvariable transmissions required.

g. Total number of nonvariable transmissions actually transmitted.

h. Total number of all type messages or charts transmitted.

6-20. AFCSR 105−2, Volume I, also provides general policies on weather message preparation, categories of messages, general terms, and facsimile operations. Volume II discusses many of these policies in greater detail, so let's turn to this volume and examine its contents.

6-21. *AFCSR 105−2, Volume II.* This volume is kept current at the weather detachment to determine the operation of your teletype or facsimile circuit within the geographical boundaries covered by the volume. In addition to providing circuit operation data, this volume lists weather communications policies and tasks that are essential for the operation of each circuit.

6-22. The following is an excerpt from Volume II and shows the circuit schedule of operations of AFCSR 105−2.

19 APRIL 1971

AFCSR 105−2.
VOLUME II

COMBINED CIRCUIT MANOP FOR COMET IIA.
A. KWRF IS DESIGNATED AS NET CONTROL STATION FOR ALL CIRCUITS ON COMET IIA.
(1) ALL TOTS INDICATE BEGINNING OF REQUIRED COLLECTION TIMES.
B. SCHEDULED OPERATIONS.

TOT	MANOP HEADING	DTG	SOURCE	GPS
0005−14				
PEH	SAXX KCOF	0015PEH	P984	75
PEH	GENERAL SCAN			

PE6H (XCP 0605–14)	SMCA KCOF	0000PE6H (XCP 0600)	P984	60
0015–18				
PE6H	FTUS 210 KWRF	0000PE6H	P986	240
PE6H	FTUS 220 KWRF	0000PE6H	P988	320
PE6H	FTUS 230 KWRF	0000PE6H	P990	240
PE6H	FTUS 240 KWRF	0000PE6H	P992	280
PE6H	FTUS 250 KWRF	0000PE6H	P978	320
PE6H	FTUS 260 KWRF	0000PE6H	P980	440
PE6H	FTUS 270 KWRF	0000PE6H	P982	360
PE6H	FTUS 280 KWRF	0000PE6H	P984	160
0020–29				
PWH (XCP 1720–29)	GENERAL SCAN			
0035–39				
PEH	GENERAL SCAN			

6-23. The circuit shown is COMET II A. Notice that under the column labeled "TOT" (time of transmission), a time period is listed (0005–14). All the weather messages transmitted over COMET II A are listed in this time period. AFCS terminology refers to weather message headings as "MANOP" headings (Manual of Operations); therefore, in this volume we also will use this terminology. The excerpt also shows the date-time group and frequency of transmission under "DTG," the circuit number source of the bulletin under "SOURCE," and the total number of groups (GPS).

6-24. As an observer, you will find Volume II of AFCSR 102–5 an absolute necessity for the proper communications procedures. In addition to knowing where to find the procedures relative to weather communications, you should know how to maintain these communications manuals and regulations.

6-25. **Maintaining Manuals and Regulations.** Maintaining these publications properly is very important. If your communications manuals are not *current* and *readable*, they are of no value to you or anyone who wishes to use them for reference. Therefore, we should consider the types of changes you are likely to encounter.

6-26. *MANAMS.* Manual amendments are issued by message for AWSM 105–2, Volumes I and II, and AFCSR 105–2, Volumes I, II, IV, V and VI. Amendments are numbered chronologically beginning with number one for the first MANAM issued at the beginning of each calendar year. When possible, amendments are limited to routine changes that affect operations and those necessary to maintain communications continuity. The effective dates of these amendments normally allow weather relays and editing centers at least three workdays advance notice. Upon receipt, you should review MANAMs for changes which affect any circuits in your operation. If the MANAM contains changes for your operation, post the applicable portions of the changed manuals without delay.

6-27. *Printed changes.* Printed changes are issued at various times throughout the year. When issued, they indicate the MANAM numbers to which the change applies.

6-28. *Revisions.* Complete volume revisions are issued as necessary. When issued, they indicate the MANAM numbers that are affected by the revision.

6-29. *Posting changes.* When posting changes, be sure you know the proper procedures. The procedures for posting changes is contained in AFR 5–31. *Publications Libraries and Operational Publications Sets.* However, more than likely your chief observer will show you the proper posting methods as part of your OJT (on-the-job-training). But he must depend on you to locate the changed areas carefully and make the changes accurately. Be sure you have the right volume before you change or delete anything. In addition to knowing the types of circuits, their use, and how to maintain the appropriate volumes, you must know the proper procedures for tape preparation. Your communications manuals also contain the latest methods in weather preparation.

6-30. **Tape Preparation.** The communications effectiveness of your station depends on correct tape preparation. To consider tape preparation for weather messages in the fullest sense, we must include policies for single station entry, multiple station entry, H-time and T-time operations. Some tape preparation policies are standard policies that apply to all weather messages and are discussed from that viewpoint.

6-31. Your responsibility toward preparing a tape consists of typing the text plus a leader and a tail. The leader describes the tape portion before the text and the tail is the section following the text. Your station's code generator automatically generates the start of the message (SOM) and end of message (EOM) codes. Station identification is part of the SOM. Tape leaders for all messages, except where noted otherwise, consist of 10 LETTERS. Tape tail must contain 7 LETTERS. The length of the leader insures proper tape positioning in the transmitter. The tail length insures that the last character of the text will pass the sensing pins in the transmitter. At present, the only exception to these standard tape functions is the EOM function for PLATF and TAF codes. With these codes the EOM functions are 2 line feeds and then the 7 LETTERS. This exception provides the user with a separation point between each report, theregy permitting the user to tear them into individual strips for filing.

6-32. Two rules apply to the text portion of your tape preparation. First, no single line of the text should contain more than 69 characters. This total includes spaces. Second, if the text must occupy more than one line, indent the second and succeeding lines by four spaces. The indentation rule, however, does *not* apply to reports of pibal, rawinsonde, reconnaissance, and rochetsonde observations.

6-33. In an earlier paragraph we mentioned H-time operations. This refers to the transmission of weather on ADCAD (Airways Data Collection and Dissemination). Tape preparation for H-time operation follows the rules outlined above for single station entry whether single or multiple line text. When you must include another station's report with your own (multiple station entry), prepare a single tape. The text for the other station follows your own text on a separate line. Include the other station's identification before its message, but do not indent it four spaces. Indent the other station's text only if it is multiple line. These tape preparation methods conclude the rules for H-time operations.

6-34. Operations during T-time include the transmission of routine delayed weather (RTD), correction messages (COR), and observations such as PIREPs, RAREPs, and TAFORs. Since an RTD or COR message is an unscheduled transmission, your tape needs an identification prefix to show what you are transmitting and the time reference of the data. The tape leader is the same as in H-time messages, but the text is preceded by the identification (COR, RTD) already noted. Multiple line texts are indented four spaces on second and following lines.

6-35. One difference in T-time message tapes is evident in the tail. To provide further separation between T-time messages, the tail includes 2 line feeds (LF) before the final 7 LETTERS. For multiple station entry, the 2-LF 7-LETTER tail follows the second station message. Between station texts, the only separation is the 2-carriage-return' (CR) 1 LF commonly used between all multiple station entries.

6-36. The special collections made during T-time such as for RAREPs or PLATFs require the first station in the collective to enter additional identification before his message. If you are the first station, your tape indicates the data being collected. Let us assume, for example, a collection of RAREPs in which you are first station. The 10-LETTER leader is followed by 2 CR 1 LF. Then the data identifier (RAREP) and geographic location (United States) lead the printed portion of the message as DSUS. The weather relay center and date-time group complete the identification. Put together, before your own text begins, the data identification is typed as:

10 LTRS (leader) 2 CR 1 LF
SDUS () KWRF DDDDDD 2 CR 1 LF

The symbol DDDDDD stands for the six-digit date-time group. All other stations following yours in the collective now are gathered under your heading.

6-37. During a portion of T-time operation, the COMET II A circuits are scanned to gather RTD, COR, or special messages. This type of scanning is called "general scan collections." The messages are unscheduled, and thus every station must identify its data content in a MANOP heading. MANOP headings vary with the type of data, such as SDUS (RAREP), UAUS (PIREP), or FTUS (FLATF). To obtain an exact heading for your message, consult AWSM 105-2. To illustrate tape preparation, we shall ignore the details of the various MANOP headings. Begin your general scan tape with the familiar—10 LTRS (leader) 2 CR 1 LF. Next line: MANOP heading DDDDDD XXX 2 CR 1 LF. Again the DDDDDD symbolizes a date-time group. The XXX symbolizes the type of message you are sending—RTD, COR, SPL.
Now you type your text:

TEXT 2 CR 4 LF 4 N's 2 CR 1 LF 7 LTRS.

This is the ending or tail. Of course, the only printed portion of the tail is the NNNN (4 N's). Prepare your tapes for transmission of weather messages according to the above listed formats.

6-38. During normal operation, you should have no difficulty making your scheduled transmission. However, occasionally, your observation is not transmitted. In this case, transmit your hourly observation as routine delayed weather (RTD). Transmit this RTD observation during T-Time and be sure it contains the term "RTD" and the time of the observation. This time must reflect the time of the originally scheduled MANOP message.

6-39. On occasion, the tape may garble while you are transmitting or perhaps you may make an error in preparing the tape. In either case, promptly prepare a correction to the tape and retransmit the correct observation. This is done in the same manner as an RTD transmission, except that the term "COR" is used instead of "RTD." Do not correct an error in an observation if a later transmitted observation obviously corrects it. For example, a transmitted special observation that contains erroneous wind data need not be corrected when a later observation reflects the correct wind. This is an acceptable practice for all weather messages except some forecast codes, such as TAF reports. However, this does not mean that if you detect an error you can wait until the next observation is transmitted, thereby eliminating the need to send a correction. You should initiate a correction immediately upon detection. For other weather data messages that are transmitted at your station, transmission formats should be maintained near the transmitter.

6-40. **Communications Terms.** The discussion of common communications terms in this section is restricted to terms that you are likely to use in your operations. Considerably more communications terms are used at communications centers; however, you don't use them in your daily operations.

6-41. *Operating signals.* Aside from making all scheduled transmissions at your station, you must be able to interpret and answer messages that are received directly from the net control station. When the COMET monitoring station, KWRF, detects a recurring circuit violation at your station, KWRF may send your station a teletype message notifying you of this violation. Therefore, you must be familiar with the following communications terms which are commonly used in these messages:

ZAA—You are not observing proper circuit discipline.
ZAI—Send (ZAI2, send test tape) (ZAI4, send traffic tape).
ZAM—Line outage.
ZBK—I am receiving your traffic (ZBK1, clear) (ZBK2, garbled).
ZDK—Following repetition of (-----) is made in accordance with your request.
ZEE—Request the following message be transmitted.
ZES—Your message has been received (1—incomplete) (2—garbled), request retransmission.
ZEV—Message is acknowledged. (Use "INT ZEV" when requesting an acknowledgment.)
ZFR—Cancel transmission.
ZLH—I am going to transmit maps — (area — time — type).
ZTB—1 transmitter-distributor inoperative.
ZTB—3 tapecutter inoperative.
ZTB—5 printer inoperative.
ZUE—Affirmative (yes).
ZUB—Negative (no).
ZUI—Your attention is invited to.

When used as an interrogation (question), the above signals are to be preceded by "INT." The signal ZEV illustrates the use of this prosign. Operating signals save valuable circuit time by condensing common terms. AWSM 105—2, Volume I, has a list of frequently used operating signals. Memorizing the list is not necessary if you know where to find it.

6-42. *Service interruptions.* Service interruptions include equipment malfunctions, circuit outage, personnel or observer error which prevents the receipt or transmission of communications traffic. Whenever your communications services are interrupted on the COMET I and II networks, promptly notify your local AT&T service test center (STC). This minimizes the inoperative time. Also notify KWRF of service interruptions; this is done by a TYPNO message.

6-43. For brevity, use operating signals with each service message. To explain specific deficiencies not covered by the operating signals, you may use plain language. All TYPNO (OK) messages are transmitted over COMET II. Prepare them to provide the following data to the net control center:

- Circuit number of the system affected.
- Description of the interruption.
- MANOP heading of the last message received prior to service interruption or the first message received after restoration of service.

6-44. Transmit all TYPNO (OK) messages to KWRF at the first available general scan period. Whenever the transmit capability of COMET II is lost, you must telephone your message to a station with a transmit capability. Prompt receipt of service interruption messages from your station allows KWRF to plan a method of transmitting the missed data to your station when service is restored. Do not assume that KWRF will announce when a programmer or local channel fails thereby eliminating your requirement to transmit a TYPNO message for the outage. Always initiate service interruption messages, because the trouble may be at your station only. Failure to notify KWRF of teletype outages results in delay of essential data that is missed during the outage period.

6-45. It would be careless to build such a fine and complex communication system without providing at the same time a plan to monitor and evaluate that system. To assure weather communications effectiveness, a monitor station has been designated for the COMET I and II teletype networks.

6-46. **Evaluation of Communications Data.** Each weather activity on the COMET network that has send capabilities is monitored daily to insure the continued effectiveness of the weather communications program. The monitoring activity is the weather relay center, KWRF, at Tinker AFB, Oklahoma. The results of this program are especially useful to both your communications operation and the COMET network in general. Your DETCO and chief observer use the discrepancy reports received from KWRF to improve their operation, which in turn improves the COMET network.

6-47. KWRF places all teletype violations in one of two categories, major or minor discrepancies. A major violation is one that interferes with or prohibits the orderly flow of weather data. A minor violation is one that does not affect the orderly flow of traffic but may cause the unwarranted use of service time or otherwise prevent efficient employment of the systems. The guidelines which KWRF provides for major and minor discrepancies over COMET I follow:

MAJOR
- Missing from H-time collection.
- Failure to transmit RTD for a missed H-time collection.
- Failure to transmit correction (COR) for a garbled entry in the H-time collection.
- Transmission of weather data not authorized on COMET I (i.e., UAUS).

MINOR
- Failure to reply to service messages.
- Unnecessary consumption of circuit time (extra impulses, etc.).
- Failure to provide required machine functions.

6-48. The COMET II circuit is also monitored by KWRF for teletype violations. The discrepancy breakdown for COMET II is as follows:

MAJOR
- Missing scheduled, obligated collection entry.
- Failure to transmit RTD when appropriate.
- Transmitting data at incorrect time period.
- Incorrect NOTAM tape preparation.

MINOR
- Failure to reply to service messages.
- Unnecessary consumption of circuit time.
- Incorrect format.
- Failure to provide proper machine functions.
- Miscellaneous errors such as failure to respond to all circuits (ALCKTS) messages.

6-49. Awarness of these violations should be part of your program to improve your teletype transmission. Evaluation of communications products extends to the facsimile charts you receive as well. In this case you are the grader. Each AWS activity that has a facsimile circuit maintains a program for evaluating the quality of the weather maps received.

6-50. This program provides a record of the quality of all facsimile charts received. Poor quality reception is thus documented and can be used to obtain improved maintenance or better equipment: As stated before, AWS personnel grade facsimile products into three categories:

Grade 3: An excellent product.
Grade 2: A good chart; meets the minimum acceptable standards of legibility. (The chart may be out of phase and graded "2," provided that not more than 10 percent of the chart is lost.)
Grade 1: A chart that does not meet minimum acceptable standards of legibility.

6-51. The local AFCS unit may request your Grade 1 charts for documenting a case of poor line quality or low maintenance support. When grading a chart, use information which is of pica type size (`Pica Size`) for legibility. The desired standard for facsimile reception is to maintain the percent of missed and Grade 1 charts to not more than 3 percent. At the end of each day (GMT) or normal duty hours, provide the local AFCS unit with a telephone report on the facsimile reception quality, if the unit is located on your base. Otherwise your report must be forwarded to the proper communications management office.

6-52. Most stations have a standard facsimile grading form near the facsimile recorder for an observer to grade the incoming charts. In addition to this evaluation of chart quality, at many stations observers are encouraged to color certain facsimile charts before they are posted. Most observers find this work enjoyable because it gives them a chance to apply their knowledge of meteorology.

6-53. Transmission of weather data on a world-wide basis needs specialists in communications. However, these communications specialists are not familiar with weather traffic. Therefore, at the communications relay centers where worldwide weather traffic is routed, specialists from weather and communications fields coordinate their effort. Our next topic looks into the duties of a weather editor at a typical relay center. Before entering that discussion, assess your understanding of Section 6 by answering the review questions in your workbook.

7. Weather Editing

7-1. Some weather observers are assigned to major or minor communications relay centers throughout the world. These centers are primarily manned by AFCS communications specialists who have had little or no weather training. The assigned observers serve as weather editors for composing weather message bulletins. Together, AWS editors and AFCS specialists carry out the mission of worldwide weather data acquisition and distribution for the Air Force.

7-2. The major relay centers, called Automatic Digital Weather Switch (ADWS) Centers, acquire large volumes of weather data from civil international circuits, AFCS circuits, and radio weather intercepts. ADWS centers provide data to friendly military services, AWS units, and civilian international relay centers. An ADWS area of responsibility usually encompasses an entire continent or an extremely large land and water mass. The minor relays, usually handle and monitor small amounts of data received from military landline or radioteletype circuits and WMO radio weather intercept broadcasts within their immediate operational area. Minor relays provide data to local areas AWS units and to the ADWS servicing their relay center.

7-3. The weather editor's tasks depend upon the type of relay to which he is assigned. An editor assigned to an ADWS is primarily a backup for the weather computer, while the editor assigned to a manual editing section is the "computer"—human variety.

7-4. **Manual Weather Editing.** If you are assigned to a manual weather editing section, you soon discover that you have stepped into an entirely different phase of the weather observing career field. You need to learn communications related skills and, at the same time, become an expert in all weather codes and weather operational procedures and requirements.

7-5. The weather measuring instruments and FMH manuals are no longer your working tools. These are replaced by various publications, such as those listed below.

- AWSM 105-2, Volumes I and II.
- AFCSR 105-2, Volumes Series.
- World Meteorological Organization (WMO) Publications.
- Federal Aviation Agency Weather & Communications Publications.
- International Civil Aeronautical Organization (ICAO) Documents.
- AWSM 100-1, Global Weather Intercepts.

However, these publications are only aids to your most valuable asset—an expert memory of the weather codes, weather message and bulletin content, and operational procedures.

7-6. Your primary task is to prepare weather messages and bulletins as directed and prescribed in AWSM 105-2, Volume II, for your area of responsibility. AFCS personnel transmit these edited weather bulletins to AWS units within your own area. At the same time, the bulletins are sent to your associated ADWS center. The ADWS center further distributes the bulletins on high-speed, 3200 words per minute (WPM), circuits and on low-speed, 75 WPM, circuits to weather units around the world. Any AWS unit in the world needing weather data will have it in minutes after it is transmitted by the relay center.

7-7. The finished weather bulletins, prepared by the editor and distributed by the relay center, become the source of weather data for AWS operating units the world over. Regardless of the size of the editing section, the timely and fluid acquisition and distribution of weather data is its primary mission.

7-8. *Data sources.* The weather editor begins his mission by screening weather data obtained from "blind,"omnidirectional world meterological organization (WMO) radio weather broadcasts as copied by AFCS personnel. He reviews, corrects, and compiles the data to meet AWS units' data requirements. These requirements are furnished by AWS units. The editor monitors the receipt of data from each intercept position. The number of intercepts could vary from only one to ten or more positions.

7-9. You, as editor, must be familiar with each broadcast and its content to advise AFCS whenever the content changes or it becomes apparent that the wrong broadcast is being copied. You need be aware of other broadcasts that your intercept positions could be switched to if the primary intercept goes off the air. You must also make a maximum effort to assure that weather data within your area of responsibility is readily available and in the system at all times.

7-10. As the data is received, either by Morse Code (CW) or radioteletype mode, it appears on standard teletype equipment. You can obtain the hard-page copy by simply clearing or tearing it off of the machines. This is your job and must not be delegated to AFCS personnel. Only by this means can you monitor the broadcast positions and, as an editor, tell instantly when a broadcast goes astray. AFCS operators can tell when a circuit is garbling, but they cannot identify good weather data. If you fail to monitor the broadcast, time may be waster in receiving useless data when an alternate broadcast could have been used.

7-11. *Intercept monitoring and reporting.* By monitoring broadcasts closely, you can detect changes in data content. Report significant data content changes of these broadcasts to higher headquarters. Headquarters puts these changes of content into the global intercept manual, AWSM 100–1, to keep it current. Also, your section initiates MANAM (manual amendment) action requests to AWS to have data added or deleted from current bulletins based on your monitoring of these broadcasts. As you monitor the broadcast and clear the hard copy from the machine, the next phase of your job begins—message interpretation and preparation.

7-12. *Message interpretation.* Message interpretation means identifying the type of data contained in the message (bulletin). Identification also includes identifying the weather stations that are reporting, the geographical area that the bulletin covers, and the time frame of the bulletin. The bulletins you receive sometimes are garbled, incorrectly arranged or in a generally unsuitable condition to be interpreted by anyone but a skilled weather editor. Common faults in these bulletins are missing or garbled FM data type identifier, geographical identifiers, WMO block identifier, or station index numbers. Perhaps you might even find different data types included under one data type heading. This is when your knowledge of the intercept broadcast contents and weather bulletin composition is put to work. Knowing the current time, the intercept positon of the source of data, and being familiar with the broadcasts, you can identify most of the errors you encounter.

7-13. *Message preparation.* Upon interpreting the received bulletins, you begin to construct the weather bulletins directed by AWSM 105–2. In some cases, you can simply change the received heading on the hard-page copy to the prescribed heading and the give the bulletin to the AFCS tapecutter for cutting and transmitting. Normally, the AWSM 105–2 prescribed bulletins must be constructed from many different messages, one line observations, forecasts, etc. You assemble them into multilined prepared messages under the required headings. The basic headings to use are varied and depend on FM data type. Some of these were explained in the first part of this volume. These headings are established by Headquarters AWS and are listed in AWSM 105–2, Volume II.

7-14. You must prepare your weather message in a clear, concise format which leaves no doubt in the mind of the AFCS communications specialist. His job is to cut a teletype tape, containing your weather message, for transmission. To prepare a message, use the editing symbols directed by the editing section. The editing symbols show where to separate lines of data, properly space the messages, divide run-together data groups, and generally "clean-up" the report so that it meets acceptable standards.

7-15. When you give the bulletin to AFCS for cutting and transmission, your primary editing function has been completed. However, you should perform a followup to see if the message is sent out on the circuits. This saves time later when you try to determine why a message you edited, and thought transmitted, was not received by the users. Followup action is a way to help AFCS personnel meet their scheduled transmission times.

7-16. Part of your job as a weather editor is to monitor all USAF military weather circuits that pass through your relay. This function assures that messages are in proper format with complete data contents. If you are notified by AFCS that a weather message has not been received, you must know which available bulletin could be used as an alternate for the missing data. When you give this data to AFCS for transmission, identify it as an alternate bulletin.

7-17. *Message withdrawal.* When a circuit is inoperative, the relay center cannot transmit data to it. This results in a backlog, at the relay center, of data that would have been sent to the circuit had it been operating. If you are monitoring the AFCS "send" (transmission) positions as you should be, you immediately become aware of a backlog caused by a circuit outage. When a backlog occurs, you issue "withdrawal notices" to the AFCS operators. A withdrawal notice simply removes obsolete or superseded data from a transmit position at the relay center. Withdrawals prevent overloading circuit time with obsolete data and allow maximum use of available time. The transmission of several hourly observations from station X, for example, to station Y, at the time the circuit is restored, would not do station Y any good. Only the latest and most current hourly observation is important. The same situation is true of all weather data. AWSM 105–2, Volume I, lists withdrawal criteria for each data type. Table 15 is an excerpt from the withdrawal criteria in AWSM 105–2, Volume I. The table illustrates that perishable data such as SA (Airways Hourlies), SD (Radar Reports), and FF (Flight Forecasts) are withdrawn after 1 hour. Data is considered perishable because it is replaced with newer information or cannot be relied upon beyond a short time period. Notice that Extended Forecasts (FE), Flight Advisories (FL), and Airep/Pirep (UA) remain in the system 3 hours. Synoptic 3 and 6 hourly (SI/SM) and much of the upper air data stays in 6 hours (Rawinsonde code UJ). A good rule of thumb is that when a more current bulletin is received for the same data type and containing the same stations or reporting points as the bulletin already on hand, then the data with the older date-time group can be withdrawn.

TABLE 15
WITHDRAWAL CRITERIA

Withdrawn after	Weather Traffic
1 Hr	FF, SA, SD, SP
3 Hrs	AB, BB, CE, CU, FE, FL, FN, HI, HM, HS, RR, SS, UA
6 Hrs	AC, AH, AS, AW, FB, FC, FT, FU, SH, SI, SM, UC, UF, UG, UJ, UN, UR, WH, WW
24 Hrs	TB, GENOT, MANAM, NOTAM

NOTE: This table is an excerpt from AWSM 105-2, Vol I. It is used for illustrative purposes and cannot be considered an accurate reference.

7-18. *URGENT and IMMEDIATE requests for data.* The editing section receives messages containing URGENT or IMMEDIATE requests for data, required by the sender, to meet other than normal operational requirements. You must maintain special logs on these types of requests to assure that all editors in the section and the section supervisor are aware of these requests, and that maximum effort is exerted to satisy the requests. You cannot question the validity of the request. Simply provide the requestor with the required data. If the data is not available within your section, refer to the editing section responsible for the area of concern and obtain the data. Also notify the requestor, by message, of action you have taken.

7-19. *Additional duties.* In addition to the duties mentioned, you are required to maintain logs and records on all bulletins originated by your section. This log shows the bulletin headings, date-time group, filing time, and individual station numbers or other identifiers from all stations included in your bulletins. You should also maintain logs of bulletin headings of alternate data tyat you transmitted, and maintain records on all URGENT or IMMEDIATE requests for data, indicating the action taken to honor these requests. You need to cooperate with AFCS personnel in the overall operation of the relay center. This includes maintaining communications publications that contain weather codes, radio weather intercept broadcasts, station identifiers, and index numbers. Also, local joint-operating instructions and radio weather intercept schedules need to be maintained. The weather intercept schedules should include acceptable alternate broadcasts to be copied if the primary intercept broadcast goes off the air or cannot be copied.

7-20. **Automated Weather Editing.** A weather editor assigned to an ADWS editing section, should be familiar with the duties of a manual relay center. However, only a part of these duties are used in editing at an automated relay. Following assignment to an ADWS, normally you receive a computer familiarization course. This course introduces you to computer language, operation, and functions. Computer weather operations and program routines are also explained in detail. On the job, primarily you identify and correct message formats, and reprocess weather information which is rejected by the computer.

7-21. Weather data comes to the computer from all sources—civilian and USAF military circuits, radioteletype or Morse (CW) intercepts. The computer program searches the data for programmed identifiers and routes the data to the appropriate code data decoder. If the computer recognizes the weather message as a bulletin requiring no reconstruction, it is routed straight past the decoders and transmitted automatically to the AWS users by the appropriate circuit at the proper time. If the data is used by the decoders for bulletin construction, the decoders automatically begin the same task the manual editor did—message preparation. Thus, the computer combines both MESSAGE PREPARATION and INTERPRETATION.

7-22. The decoder checks the bulletins and automatically stores usable data under the proper bulletin headings in the computer for later transmission. Data not recognized by the computer is rejected and sent to a monitor position in the editing section known as the "STRAYS POSITION." Your job is to correctly identify the strays. This means identifying the code type, supplying a proper data type identifier, and reinserting the data into the computer. The computer routes the data, according to the heading you supplied, to the proper decoder for bulletin construction.

7-23. Two computer programs have been developed to control the flow of data through the ADWS. These are the Master Distribution Library (MDL) program and the Station Library (STALIB) program. The MDL computer program is an AFCS development that controls the routing of all bulletins scheduled through your ADWS. The maintenance and accuracy of the MDL is the responsibility of the joint AWS—AFCS Weather Network Management Center (WNMC). The STALIB computer program is an AWS development that controls every individual weather station that reports into your ADWS. In addition, STALIB instructs the data type decoders to insert specific stations under prescribed bulletin headings. The maintenance and accuracy of the STALIB is the responsibility of AWS personnel in WNMC.

7-24. The MDL rejects a bulletin if the message heading is not listed in the MDL. The STALIB rejects data if the station is not listed in the station library. The MDL contains all bulletins scheduled into the ADWS and initially controlls the bulletin distribution. The STALIB recognizes messages only from stations listed in the ADWS Station Library. In the case of MDL failures or rejects, often the headings of the bulletins are garbled. You can, upon identifying what the message heading should be, put the proper heading on the bulletin and reinsert it into the computer. If you did your job right, the bulletin goes on its merry way. The computer, however, is nonforgiving, and if you supplied the wrong heading, you will get the message back for another attempt at identification.

7-25. Though the computer performs some of the editor's tasks, the computer's behavior is arranged by the editor. To do that, the editor has to learn some computer language. If a bulletin heading received at the ADWS is in fact a new bulletin (unlisted in the MDL), you can, by removing the received heading and using established data, type dummy headings and reinsert the data for transmission. Transmission is to the Air Force Global Weather Central (AFGWC) at Offutt AFB where all global weather data must be routed. Personnel in the MDL section survey this new bulletin, establish its degree of reliability, put the new heading in the MDL with distribution to Offutt and the new bulletin thus enters the system. After entering the system you see the bulletins only when it is garbled or transmitted under a wrong heading.

7-26. Stations rejected by STALIB could be the result of a garbled index number or ICAO/FAA identifier. If so, you must correct the garbled part and reinsert the message under the appropriate data type heading. A new station,i.e., one not in the STALIB, is put under a dummy header and sent to Offutt just as is a new bulletin. Station Library personnel survey the new station, and if possible, put it in the STALIB. At that time, it disappears from your "strays" monitor.

7-27. You are given an escape route by the computer when you cannot identify rejects. This escape is known as a "forget" routine. When the rejected, unidentifiable information, cannot be utilized or interpreted, you signal the computer to "forget" that data, and it is removed from the system.

7-28. It should be pointed out that all of the *computer* actions mentioned so far are conducted in a time frame of *microseconds*. You, the editor, have a relatively longer time to take your actions. The computer needs no time for making decisions, but it allows you exactly five minutes. When a bulletin is received, the computer sends you only the first several lines of data. Generally, you can make your decision from these few lines. If after five minutes you have not told the computer what to do with the data, the computer sends you the entire bulletin. Possibly this amounts to only a line or two more, but in most cases it will mean several hundred lines of data requiring lengthy processing by the editor. Obviously, quick recognition of the weather codes and bulletin headings permits you to deal with a smaller bulk of data.

7-29. While you are busy monitoring strays, the computer has been making other jobs for you. Routinely, several times per hour, it sends you statistical readouts which indicate how well your ADWS has been receiving data by station block numbers and data types. These "stats," as they are known, reveal the data amounts currently being received compared to amounts normally received. From the "stats" you make note of data amounts that are below normal. Notify the original data source, by message, of below normal data amounts as an attempt to bring the receipt count back up to normal.

7-30. At either a manual or automated relay, the editor acts upon URGENT and IMMEDIATE requests for data. These requests normally require you to search the data available in the computer by data type. Once you find the requested data, have AFCS route the necessary computer bulletins to the requestor for the required period. The computer, then takes over and you have honored the request. Data logs must be maintained on special requests. Then, after computer halts or emergency shutdowns, the logged entry helps get the data back into the computer when service is restored. Although this is done automatically when the computer is restored to operation, AFCS must insert the information manually. As a responsible editor, if you check to insure that the data was reinserted, your followup can eliminate a source of error.

7-31. An editor, must work closely with AFCS personnel in the overall operation of the ADWS. This involves keeping manuals, conducting surveys, etc. You do not have to issue NCIs or handle withdrawals because the computer takes care of this. Maintain a log on the number of "strays" you process during your shift. From this log your supervisor can tell how the system is working and alerts him if your workload becomes too great. He can use this information in requesting additional personnel. You are expected to monitor new circuits as they are brought into the ADWS. When programs are not working properly or when something goes astray, you are also expected to notify the weather programmers.

7-32. Understanding both the manual and automated relay editor's job, develops your overall communications knowledge. This knowledge is required to keep a steady flow of usable data to AWS units. The duties of a weather editor are often frustrating, confusing, and seemingly thankless. Nevertheless, the finished, edited products are utilized to:

- Support military worldwide flying missions.
- Assist in achieving flying safety objectives.
- Protect personnel and equipment.

7-33. To help you to recall weather editing functions, refer to your workbook and answer the chapter review exercises for Section 7.

CHAPTER 3

Electronic Data Processing

AS ONE of the worlds largest global weather facilities, Offutt AFB, Nebraska, supplies up-to-the-minute forecasts and analyses for the Strategic Air Command, Tactical Air Command, Aerospace Defense Command, Military Air Command, and other military elements. The Air Force Global Weather Center (AFGWC) personnel operate a computer-based weather report system, using a complex of high-speed, large-capacity computers. This system is supported by the Automated Weather Network (AWN), which employs communications computers to speed raw data to AFGWC at the rate of 4500 words per minute.

2. Raw data from thousands of reporting points around the world, including aircraft, surface satellite, ship, upper air, and rocketsonde reports, are received at the AFGWC from the AWN. To digest this raw data and turn out finished automated weather products, AFGWC employs computers manned and operated by weather observers. The end product is used to provide detailed support for military use around the world and to local users within the AFGWC complex such as the Severe Weather (SWX) forecast sections, Route Forecast Section and Computer Flight Plan Section.

3. To provide this worldwide weather support, the AFGWC uses four UNIVAC 1108 Computer Systems. Two systems are in a classified vault. One of these is used exclusively for classified products, but can be interchanged with the other when necessary. The other two systems, both unclassified, are used to receive raw data from the field. One of these unclassified systems is designated as the *primary* system, which enables it to receive raw data, process the data, build input tapes for the other three systems, transmit finished products to the field, and produce weather products for the AFGWC forecaster. The two unclassified systems are also interchangeable. Data from all over the world are received at the AFGWC. From the originating stations, weather data are sent, via low-speed circuits, to Automatic Weather Network (AWN) units at Fuchi AS, Japan; Clark AFB, Philippines; High Wycombe, England; Monterey, CA and Suitland, MD. From these centers, high-speed circuits send the data to Carswell AFB, TX, and from Carswell to Offutt where these data are put into the computer system for processing.

8. Processing Raw Data

8-1. The raw data as received are of no immediate value since the weather programs, which produce finished products, cannot access these data until they are processed and put into the data base. The data base provides processed data for the weather programs. The capability to receive live data, process the data, and transmit finished products to recipients all over the world is made possible by the Real Time Operating System (RTOS). This is a large and complicated program which must constantly be running in the primary computer system. Should this program fail, raw data input stops, no data can be processed and no transmission to the field can be made. In short, when the RTOS program fails, computer operations in the AFGWC comes to a near halt until the program is restarted or until the primary system is switched to a backup system.

8-2. To help you understand data processing, we must take time to explain the term "program." It is used in two ways. First, it is used to identify a set of instructions that tell the computer what you want it to do. These programs are put into the computer and serve as "electronic helpers" to the operator. We shall call this type of program a *computer program*. Secondly, the term "program" is used to identify processed weather data of a specific type. When a program of this second type is activated, it "reaches" into the computer and "pulls out" certain data such as surface data. This second type program we shall call a *weather production program*.

8-3. **Data Base.** Processing raw data for the data base is done by three computer programs called "*batches*." Batch 0 (zero) processes and stores surface data, Batch 1 upper air data, and

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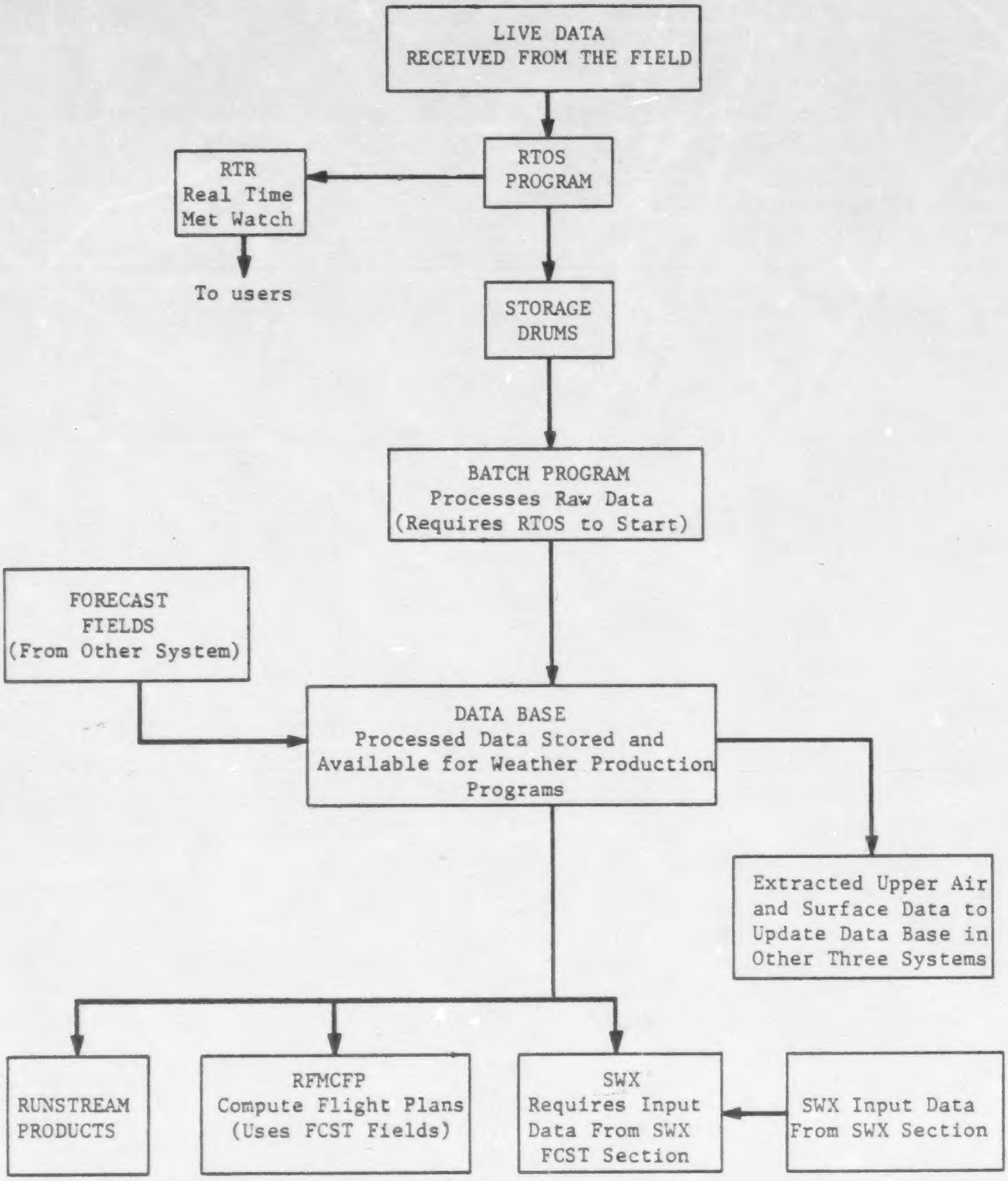
LIVE DATA RECEIVED FROM THE FIELD
RTOS PROGRAM
RTR Real Time Met Watch
To users
STORAGE DRUMS
BATCH PROGRAM Processes Raw Data (Requires RTOS to Start)
FORECAST FIELDS (From Other System)
DATA BASE Processed Data Stored and Available for Weather Production Programs
Extracted Upper Air and Surface Data to Update Data Base in Other Three Systems
RUNSTREAM PRODUCTS
RFMCFP Compute Flight Plans (Uses FCST Fields)
SWX Requires Input Data From SWX FCST Section
SWX Input Data From SWX Section

Figure 8. Data flow

Batch 2 is for solar data. As raw data are received, the information is stored on one of the mass storage drums. When the operator starts a batch, immediately the new raw data begins to be stored in a different location on the storage drum and will remain there in the data base until the next batch. Figure 8 depicts the flow of data through the primary system of AFGWC. At the top of the chart, where the data enters the system, is the RTOS program. Further along the flow, the batch computer programs process data for storage in the *data base*. From the data base, weather information reaches the users by weather production programs. Each batch is independent and has no effect on data other than the data for which batch is designed. Surface and upper air batches are scheduled to insure that current data is available for scheduled weather production runs. Solar batches, Batch 2, only produce solar data on a magnetic tape for transmission via the AWN and are scheduled to meet AWN transmission times.

8-4. The primary computer system is the only one which receives and processes raw data. Since the other three systems must also maintain a current data base, computer programs were devised to extract the processed data from the primary system, put the data on a magnetic tape, and then read these data into the other systems. For example, after each Batch 0 (upper air) has finished, a program called "TK1" is started. This program puts the upper air data on tape. These tapes act as inputs to the other systems, updating their data base. Program names, such as SH4 and TK1, are subject to change, but their purpose remains the same.

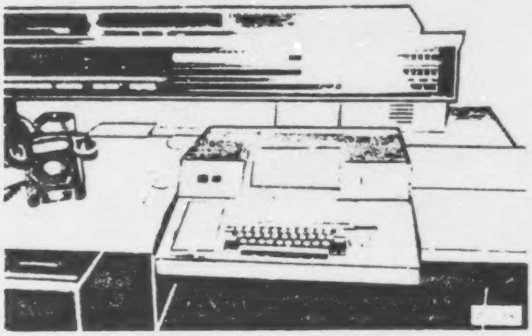

Figure 9. Operator control console.

8-5. **Programming The Computer.** With few exceptions, each scheduled weather production program can be started with a *key-in* on the operator control console, (see fig. 9.) A *key-in* is simply a command given to the computer. First, however, the computer must be instructed (programmed) to recognize and respond to various key-ins. This is referred to as putting "program files" in the computer or programming. These program files are put in the systems by tapes, and once established, the computer operator can start the weather production programs at any time with a key-in. The program files remain in the system until they are revised or deleted. If the entire system should malfunction and the program files are destroyed, then each program tape must be read back into the system as part of the recovery procedure.

8-6. For identification purposes, the computer programs (tapes) are given names. Some of the names are so lengthy that only letter abbreviations are used as identification. *Runstream* is the name of the computer program which puts the files for the scheduled weather production programs into the computer systems. Once the runstream program tape is read into the systems, the console operator can start any weather program listed on the runstream by a key-in. Runstream products are drawn directly from the data base.

8-7. The batch program puts the files into the computer system for solar data. To obtain solar data from the data base the batch program must be used. Starting a batch is an RTOS function. Runstream cannot obtain the solar data. The console operator must "talk" to RTOS. To do this he must key-in "II RTOS." This causes RTOS to respond on the consode printer with the message, "0 RTOS READY FOR MESSAGE." Now the console operator can tell RTOS what he wants. In this case he wants to start a solar batch, so he will key-in 0 Batch 2. Once the batch has started, it no longer depends upon RTOS.

8-8. **RFMCFP (Computer Flight Plan Program).** The need to better support worldwide flights brought about the development and implementation of another extremely large and complicated program called "RFMCFP." This program produces computer flight plans (CFPs) for any part of the world. Requests for CFPs are sent from the originating station to a relay center. From the relay center the CFP is sent to the 1911th Communications Center at Offutt AFB, where it is automatically punched onto a paper tape. This paper tape is fed directly into the primary computer system.

8-9. When CFP requests reach the system, a computer program called "MACCTL" takes over. MACCTL tells the computer what it wants in the flight plans, and passes these requests to the RTOS program. When the requests pass to RTOS, they start the RFMCFP program which begins producing the desired flight plans. As each flight plan is produced, it is automatically transmitted, through the 1911th Communications Center to the requestor. Normally, it takes about 30 minutes from the time that the CFP request is initiated to the time that it leaves the computer as a finished product.

8-10. The RFMCFP program *must* have RTOS running in the system or it simply will not produce and transmit the flight plans. Occasionally the RTOS program breaks down. This could be a fault in the program (software) or perhaps a machine (hardware) malfunction. In either case, if the problem is not serious, it may be corrected by removing RTOS from the system and restarting it. If the RFMCFP program is running in the system and RTOS is removed, the RFMCFP program automatically terminates. However, when RTOS is restarted, the RFMCFP program in most cases picksup exactly where it left off. Since the RFMCFP program is a high priority product, it is important to keep RTOS operating smoothly. If the problem cannot be corrected with a reasonable time (determined by the team chief and/or systems duty officer), the programming of the primary computer system must be performed by a backup system.

8-11. Perhaps at this point you can appreciate the importance of the RTOS program. Even some of the weather production programs require RTOS, not necessarily to generate the product, but to transmit it. Since RTOS is the lifeblood of the primary computer system, let's examine its operation.

8-12. First, the RTOS program files are put into the system. After that, RTOS can be brought to an active status with a key-in. There are a number of receiving devices to which RTOS makes it possible to transmit.

8-13. During initiation of the program, RTOS will want to know if any of these devices are to be "DOWNED" (not included in the transmission) and the following message will appear on the console printer. "0 RTOS*DEVICES TO DOWN." The operator must respond to this message before the initiation process can continue. If there are any devices to be downed, the operator keys in the name of the device or devices and the word "END." *Example:* a DCT2000 is to be downed. There are eleven DCTs throughout the AFGWC complex capable of receiving data from the computer system and they are labeled and numbered 1D1 (DCT 1) through 1D9 (DCT 9), and 2D0 and 2D1. For the sake of this example, the operator wants to down DCT1 so his response to the RTOS message will be "0 1D1 END." If there are no devices to be downed, the operator's response will be "0 END." Shortly after this message is answered, RTOS automatically brings all devices, except thost that are down, up to a working status and prints out a status report of each device. The status report verifies exactly what devices are operating. When the status report is completed, the RTOS program will be fully initiated and normal operations can begin.

8-14. Directly connected with RTOS is another computer program called real time relay (RTR). This program provides an automatic met (meteorological) watch program. It can sort data as the information is received in the computer system and automatically route the data to the SAC support units. Normally, these data need no processing.

8-15. The Severe Weather (SWX) program is perhaps the most critical product from AFGWC. Data for the SWX program are compiled by forecasters in the Global Weather Severe Weather Section. This information is taped by the severe weather personnel and read into the primary computer. The SWX program is normally started by the severe weather personnel by simply keying the program from the remote device, known as KSR, in their section. After the severe weather data has been put into the system the first part of the SWX program is complete.

8-16. The second part of the SWX program is started in the same manner as part one, with a key-in. However, the second part puts together the actual severe weather bulletins. The

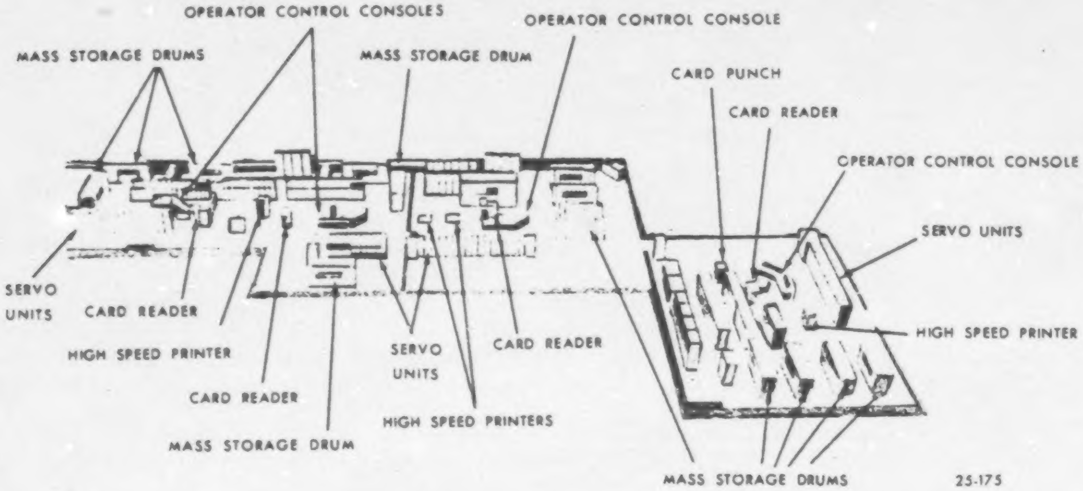

Figure 10. Systems layout.

bulletins are put on magnetic tape and transmitted to the field. A sample bulletin appears thus:

```
ZCZWNCBQ4 14P 0638Z
WWXX WWXX WWXX 3 KGWC 070632Z
FL 7-9-14
THUNDERSTORMS WITH NO HAIL AND SW GUSTS
TO LESS THAN 35 KNOTS EXPECTED IN YOUR
GENERAL AREA BETWEEN 071000Z and 071800Z

070535Z OCT KGWC
NNNN
```

As with the RFMCFP program, SWX could not run without RTOS.

8-17. **Systems Responsibility.** So far, our discussion has centered on the primary computer system. There are four computer systems in AFGWC; they are numbered Systems 1, 2, 3, and 4. A scale model of the systems layout is shown in figure 10. It is unimportant for you to associate the location of each system shown in the figure with a specific number, since the systems are basically alike. Systems 2 and 3 are in the classified vault; however, System 2 produces only unclassified data. System 1 is always designated as the primary system. System 4 is used, when necessary, as a backup for System 1 and can also run backup for System 2. Although all four systems are related, and to varying degrees must rely upon each other, we will concentrate only on Systems 1 and 4.

8-18. Each system is assigned two numbers. For example, System 1 is 1/1, System 4 is 4/4. The first number is the physical system number and remains constant. The second number is the logical system number. This number indicates the purpose for which the system is reserved. The purpose can be changed by the operator with a key-in. When we speak of System 1 as the primary system, we refer to it as *logical* System 1. These logical numbers become extremely important when System 4 must run full backup for System 1 because RTOS will not allow access to any remote receiving devices from logical System 4.

8-19. One very important step in moving the responsibility from System 1 to System 4 is to change System 4's logical system number to 1 so it will appear as System 4/1. Systems 1 and 4 have identical program files stored in their computers. This means that both systems are capable of running the same weather programs. When it becomes necessary to go into a full backup configuration, the entire System 1 responsibility is moved to System 4, which then becomes logical System 1. The entire procedure for changing systems is rather lengthy and complicated. The computer operator involved in the switch has a checklist of tasks which must be completed prior to the switch. The actual switch involves the transfer of communications capabilities from the former logical System 1 to the new System 1. The team chief or assistant team chief are the only ones authorized to switch systems, but must first insure that all items on the checklist for the systems switch have been properly completed. Once the communications link to the new System 1 has been established, normal operations can be resumed. You must understand that this is a much abbreviated explanation of an actual system switch.

8-20. If it becomes necessary for System 4/4 to partially back up System 1/1, the first weather programs chosen to be run on System 4/4 are those which do not require live transmission, since logical System 4 does not have access to the receiving devices. However, weather programs which do require live transmission *can* be run on System 4. In this case, after the program has run, a special computer program called "TPEMKR" is started which puts the weather program on magnetic tape. This tape is then taken to System 1 for transmission. Thus, with minor variation, System 4 can back up any product on the System 1 checklist without having to change logical system numbers.

8-21. **Development Programs.** We have spoken of System 4 as the backup computer for System 1. This may mislead you to believe that System 4 is in a near idle status except when required for backup. This is far from true. In volume, System 4 produces more output than the other three systems combined. The weather production of System 4's output includes AWN transmission tapes, some of System 1 transmission tapes, and weather programs which provide products for the System 4 high-speed printer (HSP). These HSP products are distributed to forecasters in the weather central and special projects branch. However, much of System 4's output is generated from the program development and testing phase of electronic weather processing.

8-22. Programs submitted for development or testing are referred to as "development jobs." System 4 is the primary "development" system and averages over three thousand development jobs per month. Of course, when System 4 is required for backup, the development jobs are preempted to favor operational weather production programs. Development jobs do not have program files in the computer system. Therefore, they must be started by reading a program card deck into the system through a card reader. The program card deck is delivered to the system along with a job sheet that identifies the programmer, the job name, and indicates whether magnetic tapes are to be used. If tapes are needed, the tape librarian supplies the required tape from the tape library, delivers the program deck, magnetic tapes, and job sheet to the system to be run. If no magnetic tapes are required, then the program deck and job sheet are delivered directly to the system after being logged in. After the job is run, it is logged out. The output, with job sheet attached, and program deck are returned to the programmer, and the magnetic tape is returned to the tape library.

9. Equipment and Operations

9-1. This section exposes to you some of the main items of equipment at AFGWC. A computer system uses punch cards; therefore, the equipment used by AFGWC is primarily punch card equipment. In this course we do not intend to outline the operating details of this equipment. We will mention only the purpose of the major items and discuss the functions performed by operating personnel.

9-2. **Data Processing Equipment.** Each of the four computer systems in AFGWC is a self-contained unit; though, as mentioned previously, they do rely upon each other. For example, Systems 2, 3 and 4 need the batched upper air and surface data from System 1 to maintain a current data base. System 2 generates forecast fields which are put on magnetic tape and read into the other systems. Systems 2 and 4 run numerous weather programs which put data on tape to be transmitted by System 1.

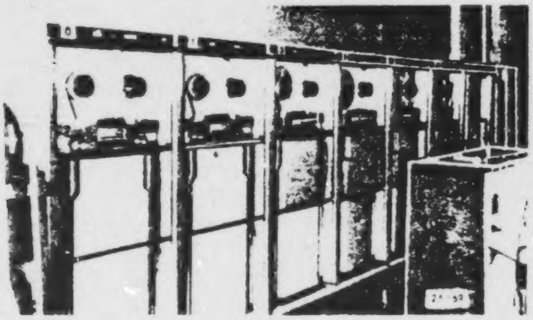

Figure 11. Servo units (tape drives).

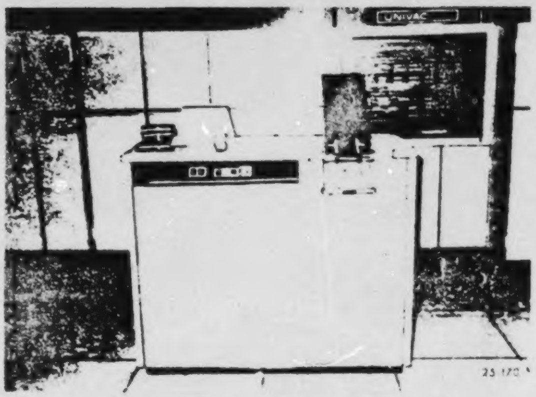

Figure 12. Card reader.

9-3. Each system is controlled by the operator control console, figure 9. From this console the computer operator controls the entire function of the system. Systems 1 and 4 each have seven servo units, figure 11. These are tape drives. Systems 2 and 3 each have six. On these, magnetic tapes can be read into the system or data can be taken from the computer and put onto a magnetic tape. A card reader, figure 12, enables program card decks to be read into the system. Program card decks give the computer instructions, but do not become part of the permanent program files within the system. Permanent program files (computer programs), you remember, are the RTOS, runstream, etc. Reading the card deck is another way of commanding the computer to start the program.

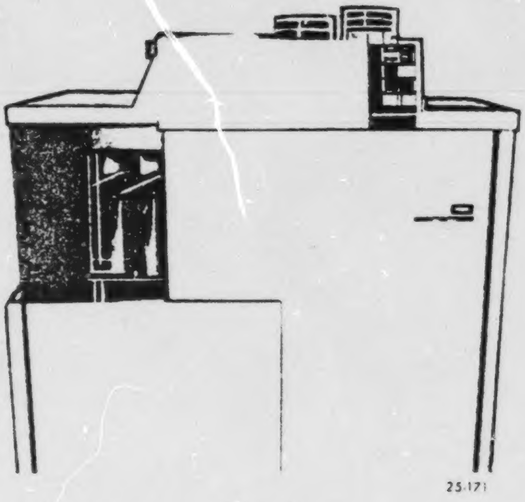

Figure 13. Card puncher.

9-4. There is one card puncher, figure 13, available for Systems 1 and 4 which can easily be changed to the system requiring cards to be punched. When each program has finished, it produces a printed output on the system's high-speed printer (HSP), figure 14. Some of this printed output is strictly informational and of no value unless the program did not run properly. Much of the output, however, is operational, such as forecast charts, Skew-Ts, etc. This output is distributed to various forecast sections in AFGWC. The DCT2000s and KSRs mentioned earlier are the remote devices. The DCTs, figure 15, are low-speed printers. Most of the weather data put on tapes in Systems 2 and 4 for transmission by System 1 are transmitted to the DCTs.

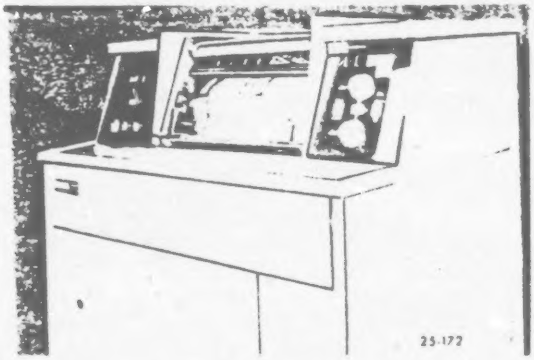

Figure 14. High-speed printer (HSP).

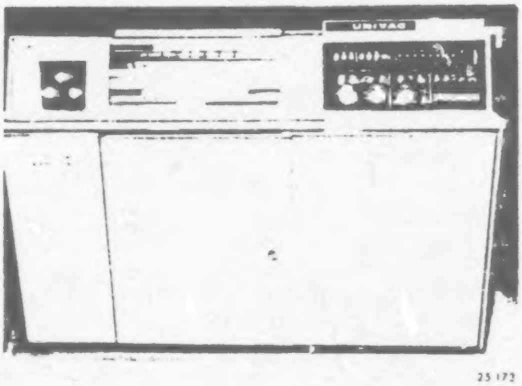

Figure 15. DCT 2000.

9-5. The KSRs, figure 16, resemble regular teletype machines. Some are used only as receivers. Others, with keyboards, are able to start certain programs in System 1 by simply keying them in. Some KSRs can punch and transmit paper tapes as well. Transmissions to and from these devices are made possible only through the use of the RTOs program on logical System 1. If expected future changes take place, System 4 also will be able to make these transmissions. Essentially, the components mentioned operate and control each system.

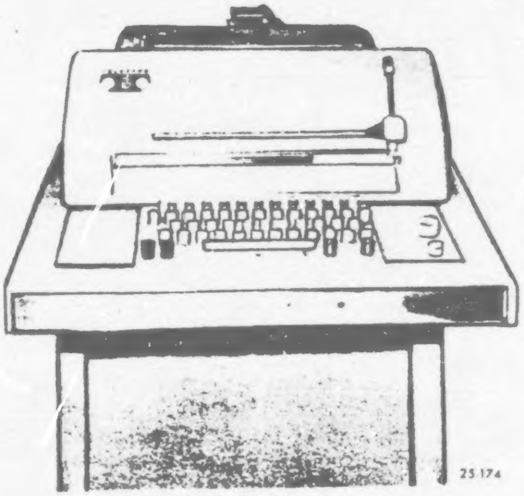

Figure 16. KSR.

9-6. **Operations.** Ideally, each computer system should be operated by three people: a console operator, a tape handler, and a printer operator. Members of the team are expected to work at any or all of these operations during a shift. Occasionally, only two people operate the computer system.

9-7. On a shift consisting of two people, one man is designated as tape handler/printer operator. The second operator is designated as the console operator. The primary duties of the console operator are monitoring the console printer, starting weather program runs at scheduled times, maintaining the systems checklist and directing the other operator(s). He also controls the number of programs running and active in the computer. System 1 normally has four active programs; but, when necessary, this number can be increased or decreased by a key-in. The more programs active in the system, the slower each one is processed. One advantage of decreasing the number of active programs is that the processing of a particular high priority program can be accelerated. On the other hand, if the system is running with four active programs and a high priority program is scheduled, the console operator can increase the active to five, allowing the priority program to start. If the operator is allowing only four programs to be active and he keys-in another one, it enters a "backlog" status, and will not actually start until one of the active programs is completed. If he wants a program which is in backlog to start ahead of others which are backlogged, he can simply change the priority of that program to the highest available. This he also does with a key-in.

9-8. A number of programs require the use of magnetic tapes, either to extract data from the system or to read data into the system. When such a program starts, it will print on the console printer the type of tape required and indicate on which tape drive the tape is to be mounted. The console operator informs the other operator(s) which tape is required and to which tape drive it is assigned. The console operator can also terminate any program in the computer. Again, he does this with a key-in. Normally he terminates a particular program only when it is not running properly. However, there are times when low priority weather programs are terminated to make room for those with higher priorities.

9-9. Monitoring the console printer is, of course, the console operator's most critical duty. He must continuously be alert to messages which require a response. These messages might pertain to a program which is not running properly or to a receiving device which is malfunctioning. Perhaps the message refers to an active program requiring his special "type-in" instructions. There are many other messages which might appear on the console printer, any one of which, if left unanswered, *could cause the entire computer system to stop*. When you consider the volume of operational weather data produced for worldwide dissemination, you can realize the tremendous responsibility placed upon the AFGWC computer operators, especially the console operators.

9-10. The tape handler mounts program tapes on servo units (tape drives), figure 11. He also dismounts tapes and delivers them to other systems or to the tape library. The printer operator sorts all printed outputs from the high-speed printer and delivers operational weather data to the forecast sections. Delivery time of all products, magnetic tapes, and printed outputs must be entered on the system's checklist. The console operator uses the checklist; therefore, he enters the delivery time. However, the printer operator must inform him when each product is delivered.

9-11. **Magnetic Tape Management.** Each magnetic tape in the AFGWC computer section is individually numbered, logged, and filed by the tape librarians. Most of the tapes are used by programmers for testing or developing new programs. These tapes are logged in with the programmer's name, filed numerically in the tape library and remain available to the programmer as long as he has use for them. When a tape is no longer needed, the programmer informs the tape librarian. That tape is "purged," which simply means that it is returned to the "work tape" status. It may then be used in another developing or testing project. Tapes, such as RTOS and runstream programs, are filed in the individual computer systems. Tapes containing classified material are stored in a separate library in the classified vault.

9-12. Careful maintenance of magnetic tapes is essential to reduce tape wear. Tapes are inclosed in plastic cannisters when not in use. Since dust and dirt on a tape affect its taping quality, the area in which these tapes are used must be kept clean and dustfree. A dirty tape may prevent a program from continuing beyond the dirty spot in the tape. When an operator suspects that a tape is dirty, he identifies it as such and sends it to the library. In the library the dirty tape is run through a tape cleaning device before it is again put into the system for use.

9-13. Rough handling of magnetic tapes, especially when they are out of their protective cannister, causes crinkles or damage. Crinkled tape stops the program the same as a dirty tape would. Blank (work) tapes, which are damaged, can be stripped down to a point just beyond the damaged area and reused. Damaged program tapes must be remade, or a backup used if one is available. Dirty and/or damaged magnetic tapes can, and have, caused delays in scheduled weather production programs. To keep these delays to a minimum, tapes must be properly handled and maintained. This responsibility belongs mainly to those assigned to the tape library. However, all personnel who use magnetic tapes—computer operators and programmers—share some of this responsibility.

9-14. **Supervision/Quality Control.** To provide up-to-the-minute weather products, forecasts or analyses, to AFGWC customers on a 24-hour basis requires a great deal of teamwork and coordination. Computer operators working with one system must continually be aware of the status of the other three systems. This means being ready, at any given moment, to run weather programs which might be scheduled for other systems. Equipment (hardware) malfunctions must be brought immediately to the attention of UNIVAC maintenance personnel for repair. Program (software) problems must also be quickly identified and brought to the attention of the system duty officer (SDO).

9-15. A system duty officer (SDO) is assigned to each system's team. Most SDOs are commissioned officers with programming experience (although NCOs with similar experience are used as SDOs at times). The SDO provides technical assistance to the computer operating staff. All problems concerning software or hardware are brought to his attention. Hardware problems are logged on an outage log. Software problems, if the SDO cannot correct them, are referred to the programmer responsible for that particular program. All problems, of any kind that cause production delays are noted in the SDO log.

9-16. The duty team chief is responsible for the actual operation of the computer. He oversees the proper manning of the systems and the quality of the products. He must be kept informed of the status of each system so that he can decide when and if weather programs are to be transferred from one system to another. Each team maintains the checklist for its system. The checklist provides the team chief with a valuable management tool. It tells him how each system is performing, whether the system is on schedule or behind, and where help from another system might be needed. It provides him with a list of magnetic tapes produced by one system and used by another, with the times that the tapes were delivered and received. The checklist shows whether transmission tapes were delivered on time. When necessary, by looking ahead of the completed portion of the checklist, the team chief can determine how late some scheduled weather products might be and inform customers of the anticipated delays.

9-17. The assistant team chief, besides helping to manage and supervise the computers, performs the major quality control for the development phase of the operations. He logs in development jobs, and when they are done, he checks them for completeness and verifies that the jobs were properly run. He places the completed development jobs in a bin outside the computer room for the programmer to pick up and at the same time logs out the completed jobs.

9-18. The most qualified computer operator assigned to a system is designated as senior operator for that system. He spot checks operational weather output for completeness and accuracy before it is delivered to the users. He also keeps the team chief informed of all output abnormalities and acts as system coordinator to the other systems. Each team consists of a team chief, assistant team chief and computer operator on each system and includes one senior operator. Two teams work parallel shifts, one in the classified vault and one for the unclassified systems.

9-19. The finished products from AFGWC are evident in weather stations throughout the world. Among the more common products are the graphic bulletins, severe weather bulletins, and clear air turbulence (CAT) advisories. These products alone indicate the importance of the Global Weather Central. However, other printouts such as pressure change charts and Skew-T plots also are produced for use in the forecast sections of AFGWC. In summary, the production of automated weather products tailored for operational use by individual customers is the aim of the AFGWC.

9-20. You have now completed your study of Volume 3 and can test your grasp of the information presented in Sections 8 and 9 by completing the chapter review exercises for Chapter 3 in your workbook.

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Manual for Radiosonde Code (WBAN) (Third ed.), 1 January 1968.

NOTE: None of the items listed in the bibliography above are available through ECI. If you cannot borrow them from local sources, such as your base library or local library, you may request one item at a time on a loan basis from the AU Library, Maxwell AFB, Alabama, ATTN: ECI Bibliographic Assistant. However, the AU Library generally lends only *books* and a limited number of AFM's, TO's, classified publications, and other types of publications are *not* available. (For complete procedures and restrictions on borrowing materials from the AU Library, see the latest edition of the *ECI Catalog.*)

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Weather Plotting and Communications

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This workbook places the materials you need *where* you need them while you are studying. In it, you will find the Study Reference Guide, the Chapter Review Exercises and their answers, and the Volume Review Exercise. You can easily compare textual references with chapter exercise items without flipping pages back and forth in your text. You will not misplace any one of these essential study materials. You will have a single reference pamphlet in the proper sequence for learning.

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Answers for Chapter Review Exercises

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ECI Form No. 17

CHANGES FOR THE WORKBOOK:

Page	*Chapter*	*Item*	*Correction*
4	1	27	Delete and replace with new question: "27. How is the amount (Ns) of a layer reported in METAR code for 2/8 stratus and 1/8 stratocumulus at the same level? (1-57)"
4	1	29	Change paragraph reference to (1-58).
4	1	30	Change paragraph reference to (1-61).
22	1	27	Change answer to read "Three."

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STUDY REFERENCE GUIDE

1. *Use this Guide as a Study Aid.* It emphasizes all important study areas of this volume. Use the Guide for review before you take the closed-book Course Examination.

2. *Use the Guide for Follow-up after you complete the Course Examination.* The CE results will be sent to you on a postcard, which will indicate "Satisfactory" or "Unsatisfactory" completion. The card will list *Guide Numbers* relating to the items missed. Locate these numbers in the Guide and draw a line under the Guide Number, topic, and reference. Review these areas to insure your mastery of the course.

Guide Numbers

Guide Numbers 300 through 313

300 Introduction to Plotting Weather Charts; Surface Charts: Land Synoptic Code; Mandatory Groups; pages 1-5

301 Surface Charts: Supplemental Groups; Ship Synoptic Code; Airways Code; pages 5-9

302 Surface Charts: METAR Code; Local Area Charts; pages 9-15

303 Upper Air Charts: Radiosonde Code; Part A (Radiosonde Code); pages 15-20

304 Upper Air Charts: Part B (Radiosonde Code); Parts C and D (Radiosonde Code); TEMP SHIP (Radiosonde Code); Upper Wind Code; pages 20-25

305 Upper Air Charts; Constant Pressure Charts; Thermodynamic Diagrams; Winds Aloft Chart; Hodograph Chart; pages 25-28

306 Aircraft Codes; pages 28-35

Guide Numbers

307 Introduction to Weather Communications and Editing; Weather Communications Systems; pages 36-41

308 Weather Data Requirements; pages 42-43

309 Communications Manuals and Procedures: Types of Communications Manuals and Regulations; AFCSR 105-2, Volume II; pages 43-47

310 Communications Manuals and Procedures: Maintaining Manuals and Regulations; Tape Preparation; Communications Terms; Evaluation of Communications Data; pages 47-51

311 Weather Editing; pages 52-55

312 Introduction to Electronic Data Processing; Processing Raw Data; pages 56-61

313 Equipment and Operations; pages 61-64

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CHAPTER REVIEW EXERCISES

The following exercises are study aids. Write your answers in pencil in the space provided after each exercise. Immediately after completing each set of exercises, check your responses against the answers for that set. Do not submit your answers to ECI for grading.

CHAPTER 1

Section 1

Objectives: To be able to describe the various *surface weather code* formats, to identify regional coding variations, and to apply this knowledge in plotting charts with adequate coverage.

NOTE: Review exercises 1 through 14 are related to land synoptic code.

1. Why is it necessary to plot smaller on some surface charts than others? (1-1, 2)

2. What publication describes the various synoptic codes and the encoding of the individual elements? (1-3)

3. Why is it necessary to be aware of the regional variation in synoptic code? (1-4)

4. In land synoptic code, how many groups are considered mandatory? (1-5)

5. What does a sky cover and wind group reported as "62710" indicate? (1-7–9; Table 1)

6. What does the weather group "ww" reported as 19 indicate? (1-11)

7. In synoptic code, is the pressure encoded? (1-13)

8. What does the first digit of the cloud code group (N_h) represent? (1-15)

9. What is the last mandatory group for all regions? (1-18, 19)

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10. The supplementary groups basically accomplish the task of ________________ or adding __________ the information in the mandatory groups. (1-20)

11. In the supplementary group $7RRR_tS$, what does the "RR" represent? (1-22)

12. What regions report the cloud layer group $8N_sCh_sh_s$? (1-26)

13. What does the supplementary group "2////" represent? (1-30)

14. Within Region IV, what indicator group is the last coded group that is reported? (1-36)

NOTE: Review exercises 15 through 18 pertain to ship synoptic code.

15. When looking at synoptic code, what is your *first clue* that you are looking at ship synoptic code? (1-40)

16. When plotting ship synoptic code ($YYGGi_w$), what does the group (i_w) represent if it is encoded "0" or "1"? (1-41)

17. What is the main difference between the temperature of sea data reported in the "0" and "1" indicator groups? (1-43, 44)

18. What do the digits (E_sE_s) of the ice data represent? (1-45)

NOTE: Review exercises 19 through 21 pertain to airways code.

19. Basically, how many plotting models are provided for airways code? (1-46)

20. What code format is generally used in the continental U.S. to plot local surface charts? (1-46, 47)

21. What are several items that might cause a forecaster to request a local area chart? (1-48)

NOTE: Review exercises 22 through 39 pertain to METAR code.

22. When is it mandatory for a time group to be included with METAR reports? (1-50)

23. What does a wind group of "27050" indicate? (1-51)

24. How is the visibility data reported? (1-52)

25. How is runway visibility reported? (1-53)

26. What does the data 95TS indicate? (1-54)

27. What is the maximum number of cloud layers that may be sent with one METAR report? (1-57)

28. How many reportable cloud types are there in METAR code? (1-58)

29. In what situation may two cloud types at the same level be reported? (1-60)

30. How is a temperature of −3° C. reported? (1-62)

31. What difference is there between METAR and SPECI reports? (1-66)

32. How does the LASC differ from the LAWC? (1-68)

33. List four surface weather codes that can be plotted on locally produced charts. (1-70)

34. If two pilot reports are received for the same location and report the same phenomena, what should be done? (1-74)

35. Why are pilot reports of great value to the forecaster? (1-75)

36. How are radar reports plotted on a surface map? (1-77; Fig. 3)

37. What are the three items that should be entered when plotting the significant parts of a radar report? (1-77)

38. On what chart would an observer normally plot a severe weather advisory and when? (1-78, 79)

39. Why is it important to know the correct chart scale when plotting severe weather advisories on locally prepared charts? (1-79)

Section 2

Objectives: To be able to explain and decode radiosonde and upper wind codes; and to describe how constant pressure charts, wind aloft and hodograph charts, and Skew-T diagrams are plotted from data sources such as radiosonde code and upper wind code.

1. What is the purpose of upper air charts? (2-1)

2. Into how many parts are radiosonde codes divided and how are they transmitted? (2-4, 5)

3. What parts of the radiosonde code contains the mandatory levels? (2-6)

4. What are the standard observation times for radiosonde code? (2-7)

5. Decode the following message identification: TT 78001 72248. (2-10–13)

6. In which part of radiosonde code can you find surface wind data? Name the indicator for the surface level in that part. (2-14)

7. Decode the following Part A mandatory level height groups:
a. 85551.
b. 701176.
c. 40755.
d. 20229.
(2-17, 18)

8. The value of "TT" indicates the temperature in whole degrees __________________ for appropriate levels. (2-23)

9. Decode the following radiosonde temperature and wind groups: 28664 07505. (2-24–28)

10. What does 88999 mean in the tropopause section of Part A? (2-29, 30)

11. Which of the two indicators for maximum wind shows that the maximum wind level is below terminating level? (2-31)

12. How would you interpret a maximum wind section containing four groups of data? (2-32)

13. What is the primary difference between Part A and Part B of the radiosonde code in determining the levels transmitted? (2-34)

14. The format for Part A and Part B are identical except for what one item? (2-35)

15. If the forecaster asked you to extract the surface level data from a radiosonde code report, how would you locate this data? (2-36)

16. What is the lowest pressure which may be reported as a significant level in Part B of the radiosonde code? (2-37)

17. A radiosonde report in the U.S. reported 31313 25hhh TTT_a ddfff in Part B. What data do these groups transmit? (2-38)

18. What kind of data follows the 51515 group in the radiosonde code? (2-39)

19. What data is transmitted in the early transmission message? (2-40)

20. When the stability index is coded between 01 and 40, is the atmosphere stable or unstable? (2-41)

21. What does the additional data group 10196 mean? (2-42)

22. What part of the radiosonde code contains the mandatory and significant data above 100 mb? (2-44)

23. The geographical location and station numbering of a ship station cannot be expressed by an (IIiii) identification section. What replaces this group for a ship station? (2-49)

24. What is meant by a Marsden Square? (2-51)

25. What is the code name for upper wind data from a land station? (2-52)

26. Upper wind data is normally available how many times a day and what are these times? (2-54)

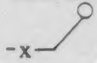
27. What does the identification code of "3" in upper wind code indicate? (2-55)

28. The mandatory levels for upper wind code is the same as __________ __________. (2-56)

29. If the maximum wind in Part A for upper wind code ($H_m H_m H_m H_m$) is encoded as "1400," what is the actual height and how did you arrive at this figure? (2-61, 62)

30. When plotting constant pressure charts the darkened circle means the dewpoint depression is __________ or __________. (2-66)

31. What is wrong with this plotted wind? (2-67)



32. What is the sequence of colors for plotting three soundings on a Skew-T? (2-69, 70)

33. How should winds be plotted on the Skew-T chart? (2-74)

34. What is the purpose of a winds aloft chart? (2-78)

35. What is a hodograph chart and what is its purpose? (2-79)

Section 3

Objectives: To be able to identify the elements of each aircraft code and their proper usage in the plotting function on local area charts.

1. What code is used for recording weather parameters on scheduled weather reconnaissance flights? (3-2)

2. Of what value is it to be familiar with the identification and time groups of RECCO codes? (3-5, 6)

3. Decode the following portion of a RECCO code report: 97779 12304 21363 41532. (3-5–9)

4. Why is it important to check the RECCO coding instructions for the d_t value? (3-10)

5. How is a calm wind encoded for direction? (3-11)

6. How are negative temperatures encoded in the temperature and weather group (TTT_uT_{uw})? (3-12)

7. What method is used to determine the pressure level in the RECCO observation? (3-13)

8. When more than three layers of clouds are reported in RECCO cloud data, what is required? (3-15)

9. What is the primary difference between the "4" and "5" indicator groups in RECCO code? (3-18–20)

10. What is the primary difference between the 6, 7, and 8 indicator groups? (3-22–30)

11. When would use of the abbreviated RECCO plotting model be most appropriate? (3-32)

12. Why is it imperative to use the precise coding format for COMBAR reports? (3-33)

13. What form is used to record COMBAR code? (3-36)

14. What is the main difference in the coding instructions for latitude and longitude in COMBAR reports as compared to other aircraft reports, such as RECCO code? (3-37)

15. What would an aircraft height reported as "175" in COMBAR code actually represent? (3-38)

16. How would a temperature of +10° C. be reported in COMBAR code? (3-39)

17. What does the letter identifier prefixing wind data in COMBAR reports indicate? (3-40)

18. What would a D-value of PO150 at 300-mb level indicate in a COMBAR report? (3-41)

19. What do the following plain language groups mean in the COMBAR report?
    a. "EXRINT" (BBBbbb).
    b. GOOD (VVVV).
    c. CBB ($N_1N_2N_3$).
    (3-42–44)

20. When contrails are observed, they are reported as "PRST" or "NPRS"; what is the meaning of these plain language remarks? (3-46)

21. When is aircraft heading data reported in COMBAR reports? (3-47)

22. What form is utilized by military aircraft to record AIREP code? (3-50)

23. What information is deleted from AIREP code before transmission over teletype and why? (3-52)

24. On what type of chart is AIREP code usually plotted? (3-53)

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CHAPTER 2

Sections 4 and 5

Objectives: To show a knowledge of the use of AWS, AFCS, and communications manuals and regulations in determining weather data availability, message content, and data sources. Further, to be able to recall the general operating procedures of the military and civilian weather communications networks and the observer's relationship to these networks. Further, to be able to describe the principles involved in the worldwide exchange of weather data.

1. Long-line dissemination of weather data between military weather stations is done by ____________ ____________ ____________ ____________, which is operated by weather editors and AFCS personnel. (4-1)

2. What are the USAF/DCS Weather Communications Networks? (4-2)

3. What is the mission of the USAF/DCS Weather Networks? (4-3)

4. What communications responsibilities does AFCS have in the collection and dissemination of military weather data? (4-4)

5. What are two primary services COMET I provides a typical weather detachment? (4-7,8)

6. Why are COMET II A and COMET II B considered as two independent circuits? (4-9)

7. As an observer, how do you use COMET II A and B? (4-10)

8. What is the primary service COMET III provides? (4-12)

9. As an observer, what is your main task in relation to the FAA weather communications? (4-15)

10. What is the purpose of the Modernized Weather Teletypewriter Communications System (MWTCS)? (4-16)

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11. What type of weather data is received over Service A? (4-17)

12. What type of weather data is received over Service C? (4-18)

13. As an observer, what is the significance of your weather station duties to AWN? (4-19)

14. Where is the "hub" of AWN located? (4-22)

15. What is the purpose of the ATN circuit? (4-24, 25)

16. What is the objective of the facsimile systems? (4-26)

17. Which facsimile circuit is considered the basic weather graphics network? (4-29)

18. What facsimile circuits transmit satellite charts? (4-31, 32)

19. Which facsimile is a military network? (4-33)

20. How is the quality of facsimile charts evaluated by weather personnel? (4-35, 36)

21. What are the four major categories of weather data requirements? (5-1)

22. Who is responsible for establishing the weather data requirements? (5-2)

23. How many categories are there under which data requirements may be submitted and what are they? (5-2)

24. If a data request is necessary to meet normal mission changes, which category would it be submitted under? (5-3)

25. Requests for routine data are made on what form? (5-3)

26. If a data request is needed to meet requirements generated by "no notice" exercises, which category would it be submitted under? (5-4)

27. Under what conditions may the immediate category be used? (5-5)

28. When using the immediate category how should the request be accomplished? (5-6)

29. Who is responsible for the overall management of the data requirements program? (5-7)

30. How often must copies of individual unit data requirements be forwarded for certification? (5-8)

Section 6

Objectives: To show a knowledge of the use of AWS WBAN manuals and AFCS regulations in determining weather data availability, message content, and data sources. Further, to be able to describe the formats for tape preparation, identify operating signals, and describe communications evaluation.

1. Which volume of AWSM 105–2 series applies to all units, regardless of location? (6-1)

2. What subject does AWSM 105–2, Volume I, deal with? (6-2)

3. What publication would you use to decode a weather message heading? (6-2–4)

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4. How is a weather message heading indicated on bulletins of similar content for the same geographical area? (6-5)

5. What does the "ICAO" identifier in a weather message heading tell you? (6-6)

6. What is the primary reason for the network withdrawing weather messages from the circuit? (6-8)

7. What action should you take if you are responsible for originating a particular weather message but it is not ready for transmission? (6-10)

8. What does "4GR 300" indicate about a message found in Volume II of AWSM 105–2? (6-12)

9. What is the meaning of the term "half-duplex circuit"? (6-15)

10. Who is responsible for enforcing circuit discipline on weather circuits? (6-16)

11. What type of report is prepared by a weather relay center for substandard performance of a station? (6-19)

12. What publication should you use to find the actual time a weather message is transmitted over COMET II? (6-21–23)

13. Why is it so important to properly maintain your communications manuals and regulations? (6-25)

14. What is the meaning of the abbreviation MANAM? (6-26)

15. When posting printed changes and revisions what tells you their currency date? (6-27, 28)

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16. What regulation concerns the posting of changes? (6-29)

17. What is the purpose of having 7 LETTERS as a tape tail on each weather teletype tape that you prepare? (6-31)

18. What difference exists between the tape tails for H-time and T-time reports? (6-35)

19. For a collection of RAREPs, who puts the data identifier at the beginning of the collective? (6-36)

20. When you miss a scheduled airways observation (hourly) transmission, what action must you take? (6-38)

21. In what case are corrections to weather messages transmitted? (6-39)

22. What manual provides a list of operating signals? (6-41)

23. What are some of the essential data that must be included with TYPNO(OK) messages? (6-43)

24. What criteria does a KAWN use in determining whether a teletype violation is a major or minor violation? (6-47)

25. If you prepare a teletype tape with SOM functions in excess of the standard 10 functions, what type of discrepancy would you likely receive from KAWN? (6-47, 48)

26. A facsimile chart may be graded as 2 if not more than ______________ percent of the chart is lost. (6-50)

Section 7

Objectives: To be able to define terms such as message interpretation and preparation, withdrawal, alternate bulletin, urgent or immediate requests, strays, MDL, STALIB, STATS, and "forget" routine; further, to be able to list weather data sources and describe editing duties such as monitoring and maintaining logs.

1. Why are weather observers assigned as editors to major and minor communications centers? (7-1)
2. What is the meaning of the abbreviation ADWS? (7-2)
3. What types of weather communications circuitry provide data to an ADWS? (7-2)
4. For whom do the minor relays provide weather data? (7-2)
5. What are the primary working tools for the weather editor? (7-5)
6. What manual prescribes the weather messages for editing sections? (7-6)
7. Why is it so important for the weather editor to monitor the intercept positions? (7-10, 11)
8. What is meant by the term "message interpretation"? (7-12)
9. What is meant by the term "message preparation"? (7-13)
10. What is an alternate bulletin? (7-16)
11. What is message withdrawal? (7-17)
12. What are URGENT or IMMEDIATE requests for data? (7-18)

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13. Why must special logs be maintained on URGENT and IMMEDIATE requests for data? (7-18)

14. Who maintains logs and records of alternate bulletins? (7-19)

15. What is the primary duty of a weather editor assigned to an automated editing section? (7-20)

16. What data sources are available to the manual and automatic weather editing sections for weather message preparation? (7-8, 21)

17. What is a "strays" position? (7-22)

18. What is the MDL? (7-23)

19. What is the STALIB? (7-24)

20. What is a "forget" routine? (7-27)

21. What is the purpose of a "STATS" routine? (7-30)

CHAPTER 3

Sections 8 and 9

Objectives: To be able to describe the various computer programs and systems, identify the operations of data processing equipment, identify the duties of computer personnel, and describe tape management.

1. What program makes it possible for the primary computer system to receive and process raw data, and transmit finished products? (8-1)

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2. Where is the raw data put after batch processes it? (8-1, 3)

3. What is the name of the program which processes raw data? (8-3)

4. Since the primary computer system only can receive and process raw data, how do the other three systems maintain a current data base? (8-4)

5. What are "program files"? (8-5)

6. What "files" does the runstream program tape put into the computer systems? (8-6)

7. What program *must* be running in the computer in order to start a batch? (8-7)

8. What does the "RFMCFP" program produce? (8-8)

9. What program *must* be running in the computer before the RFMCFP program can produce its information? (8-9)

10. If it becomes necessary to remove the RTOS program from the computer while the RFMCFP program is running, how will the RFMCFP program be affected? (8-10)

11. Once the RTOS program tape has been read into the computer and program files established, how is RTOS brought to an active status? (8-12)

12. What does the real time relay (RTR) program do? (8-14)

13. Where is this data obtained for the Severe Weather (SWX) program? (8-15)

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14. Part one of the SWX program puts data into the computer system. What does part two do? (8-16)

15. Of the four computer systems in AFGWC, which one produces all classified products? (8-17)

16. When System 4 is required to run full backput for System 1, why must the logical system number be changed to "1"? (8-18)

17. Can weather programs which require live transmission on System 1 be run on System 4 without changing logical system numbers? (8-20)

18. Since System 4 is considered the backup system for System 1, does this mean that System 4 remains idle until required for backup? (8-21)

19. What computer system is used for "development jobs"? (8-22)

20. How are development jobs started in the computer? (8-22)

21. What component controls the entire computer system? (9-3)

22. Which of the system's team members maintains the system's checklist? (9-7)

23. Which duty of the console operator is considered most important? (9-9)

24. Who has the primary responsibility of logging and filing magnetic tapes? (9-11)

25. Why is careful maintenance of magnetic tapes important? (9-12)

26. What is the responsibility of the systems duty officer (SDO)? (9-15)

27. Upon whose shoulder does the overall responsibility for the actual operation of the computers fall? (9-16)

28. What is the team chief's most valuable management tool? (9-16)

ANSWERS FOR CHAPTER REVIEW EXERCISES

CHAPTER 1

Section 1

1. It is necessary to vary the size of your plotting because some surface charts cover a much larger area and are drawn on a smaller scale. If you plot large, it would obscure many stations on a small-scale chart.

2. The *Federal Meteorological Handbook No. 2* describes the various regional code, as well as coding of individual elements.

3. You must know the regional variations in order to correctly decode synoptic code.

4. The first six groups are mandatory for all regions.

5. "6/8" total sky cover, wind direction 270°, and windspeed of 10 knots.

6. That a funnel cloud occurred during that observation time period.

7. The pressure is encoded to the nearest tenth of a millibar.

8. The total amount of all low clouds present, or the total amount of all middle clouds when low clouds are not observed.

9. The dewpoint and pressure tendency group (T_dT_dapp) is the last mandatory group.

10. Supplementing; to.

11. Most areas of the world report the total amount of precipitation for the last 6 hours (RR) in either hundreds of an inch or in millimeters.

12. Regions IV and V, at designated stations in these regions.

13. Precipitation occurred during the previous 24 hours, but the amount cannot be accurately determined.

14. The "4" indicator group is the last coded group that is reported.

15. The synoptic code for ships contain the identifier "SHIP" or the actual name of the ship.

16. If the digit reported for (i_w) is either "0" or "1" the winds are in meters per second rather than knots.

17. The temperature of sea data in the "0" indicator group is coded in half degrees Celsius, whereas the "1" indicator group provides the temperature of the sea to the nearest tenth of a degree and is read direct if the temperature is above 0° Celsius.

18. The digit (E_sE_s) of the ice group gives the ice thickness in centimeters.

19. Four plotting models are provided for plotting airways code.

20. Airways code is used almost daily at most continental U.S. weather stations for plotting local surface charts.

21. They may require a special local chart for tracking a fast moving front, a depiction of ceiling layers in the area, a severe weather outlook, or an analysis of precipitation amounts and rate of movement.

22. When the actual report time differs from the collective time by more than 10 minutes.

23. The mean direction and speed of the wind for the 10-minute period preceding the observation was 270° at 50 knots.

24. In 100-meter increments up to 5000 meters and 1000-meter increments from 5000 to 9000 meters.

25. Runway visibility is repeated in meters.

26. It means thunderstorm is occurring at the time of the observation.

27. Three if no cumulonimbus clouds are present; four if they are present.

28. There are 10 reportable cloud types in METAR code.

29. If the lesser cloud type (amount) is cumulonimbus, it is reported separately.

30. A temperature of minus three is reported "MO3."

31. SPECI reports differ from METAR reports by including a time with each report and omitting the temperature/dewpoint and altimeter data

32. The LASC requires the use of a more complete analysis; hence it requires more plotting elements.

33. Airways, METAR, ship synoptic, and land synoptic.

34. Plot the latest report.

35. PIREPS are of great value to the forecaster because the pilot is in a position to detect severe weather development that has not been previously identified on radarscopes.

36. Outline the dimensions of the radar echo area and enter the significant parts of the report within the outlined area.

37. The reports should include the *movement*, *size*, and *intensity*.

38. On a LAWC, if requested by the forecaster.

39. To insure that the advisory is plotted at the correct location.

Section 2

1. Upper air charts are used for forecasting loud thunderstorm activity, because thunderstorm activity is based primarily on variances in the atmosphere.

2. Radiosonde code is divided into four parts, A, B, C, and D. Parts A and B are in the *first transmission* and C and D are in the *second transmission.*

3. Parts A and C are composed of mandatory levels.

4. The standard times are 0000 and 1200 GMT.

5. TT – Radiosonde code, Part A.
78XXX – Windspeeds reported in knots.
78XXX – Sounding taken on 28th day of the month GMT.
XXC0X – Standard time of observation at 0000 GMT.
XXXX1 – Winds reported up to and including 100 mb.
72XXX – Geographical block area 72 (United States).
XX248 – Station identifier (Shreveport, La.).

6. Part A, indicator 99.

7. *a.* 850 mb at 1551 meters MSL.
b. 700 mb at 3176 meters MSL.
c. 400 mb at 7550 meters MSL.
d. 200 mb at 12290 meters MSL.

8. Celsius.

9. Temperature: 28.6° C.
Dewpoint depression: 14°.
Wind direction: 75°.
Wind speed: 5 (knots or meters per second according to units specified in identification section).

10. No tropopause observed below 100 mb.

11. 77.

12. The first two groups represent the absolute maximum; the last two groups add a secondary maximum.

13. In Part A the number of levels are fixed (standard levels), while Part B contains as many levels as necessary to show the significant changes of temperature or humidity within the sounding.

14. The exception is the wind indicator, I_d. No winds are included in Part B; therefore, I_d is always reported as a solidus.

15. Surface level data can be found in two places in a radiosonde code report. It is the first standard isobaric level and is prefixed by a "99" indicator. It is also repeated as the first significant level, but in this case is indicated by a "00."

16. No significant levels for pressures lower than 100 mb are reported in Part B.

17. The height, temperature, dewpoint depression, and winds for the 250-mb level.

18. The groups contain data in regionally adopted code form that cannot otherwise be included in the message.

19. The 850-, 700- and 500-mb standard levels and the stability index.

20. Stable.

21. Early transmission of 850-, 700-, 500-mb data and stability follows.

22. All mandatory levels above 100 mb are reported in Part C, and significant levels in Part D.

23. The identification section is replaced by the ships latitude, longitude, and Marsden Square number.

24. It is an area on a map with the sides represented by 10° of longitude and 10° latitude and is used to identify ship position.

25. The code name for upper wind data is PILOT.

26. Upper wind data is normally available four times a day at 0000Z, 0600Z, 1200Z, 1800Z.

27. It means the method of obtaining the wind report was with radar.

28. Radiosonde code.

29. The true height can be obtained by multiplying the reported value by 30 (1400 X 30 = 42,000 feet).

30. Five degrees; less.

31. The "X" denoting a missing windspeed should be plotted at the end of the wind shaft.

32. Black, blue for 12 hours later, and red for 24 hours after black trace.

33. Wind shafts and barbs should be used and they should be plotted in the same color as the sounding curve.

34. A winds aloft chart is used to depict the wind field over a large horizontal area.

35. A hodograph chart is a wind chart that shows the *vertical* distribution of winds above an observation point.

Section 3

1. RECCO code is used to record weather parameters on scheduled weather reconnaissance aircraft flights.

2. These groups indicate the height units used for the report and the type of humidity data reported.

3. The identification group 97779 indicates radar was used for determining heights in meters; the time group 1230 indicates 1230 GMT time, code figure 4 at the end of time group indicates dewpoint is available; the report is for Monday (2); the aircraft is in the Northern Hemisphere (1) at 36.3° N. and 41.5° W; turbulence value of 3; and the f'_c flight condition value is 2.

4. The d_t value tells you whether the winds are off position.

5. When the wind is calm, "00" will be coded for direction.

6. Negative temperatures are coded with "50" added to the temperature.

7. The value reported for "j" is a code value that is used to identify the pressure level for the observation.

8. When more than three layers are reported, an additional "1" group is sent to report the amounts of the additional layers.

9. The "5" indicator group reports surface wind direction to eight points of the compass and speed in Beaufort terms. It also reports information on the state of the sea and direction of the swell. The "4" indicator group reports wind direction and speed only.

10. The "6" indicator group reports significant weather on or off course, whereas the "7" indicator group reports icing information, and the "8" indicator group reports radar echo information.

11. The abbreviated plotting model is generally used when plotting the observations on the surface chart.

12. The slightest deviation in format prevents automatic decoding by the computers.

13. AWS Form 81 is used to record COMBAR reports.

14. The latitude and longitude are reported to the nearest minute in COMBAR reports, rather than to the nearest tenth of a degree as in RECCO code.

15. A flight level of 17,500 feet.

16. It would be coded as "P10."

17. The navigational method used to determine the wind data.

18. The height of the 300-mb level is 150 feet above the standard height of the 300 mb.

19. *a.* Turbulence; extreme, intermittent.
    b. Visibility; over 3 nautical miles.
    c. Sky cover; clear below flight levels, broken at flight level, and broken above flight level.

20. "PRST" means persistent contrails, and "NPRS" means nonpersistent contrails.

21. Aircraft heading data is reported when clear air turbulence is reported.

22. MAC Form 193 is used to record AIREP code by military aircraft.

23. Next position information is deleted because it contains nothing of meteorological significance.

24. AIREP code is usually plotted on constant pressure charts.

CHAPTER 2

Sections 4 and 5

1. Automatic collection-dissemination system.

2. The USAF/DCS weather networks are comprised of the weather teletype, AWN, facsimile, and global intercept and broadcast networks.

3. The mission of the USAF/DCS weather Networks is to provide communications service for Air Weather Service in support of their global mission and other DOD agencies.

4. AFCS is responsible for maintaining detailed communications instructions and operating schedules.

5. COMET I provides a means of disseminating observations by long line from ROS. In addition to this, the COMET I receive-only termination at the weather station provides the forecaster with a source of current observations.

6. COMET II B is connected to COMET I during hourly airways collections periods for the purpose of relaying airways data. Following this period, COMET II B becomes as independent circuit for the dissemination of data collected on COMET II A.

7. You use COMET II B to disseminate support data, such as PIREPs, RAREPs, NOTAMs, and TAF reports, by long-line transmission from your station. You receive incoming operational weather support data over COMET II.

8. COMET III provides a method of receiving operational support data such as, forecasts, upper air data, synoptic data.

9. As an observer, my main task is to receive the incoming bulletins from the FAA circuits and to file them.

10. The MWTCS consolidates the circuit control and relay functions of FAA communications circuits–services A, C, and O.

11. The Service A civilian weather circuit transmits hourly airways reports from throughout the United States. In addition, Service A transmits operational support data such as PIREPs, RAREPs.

12. Service C transmits synoptic code data, upper air data, and other data coded in international weather code forms.

13. As an observer, the quality of my transmitted weather messages determines the success of AWN.

14. The "hub" of AWN is the ADWS center located at Carswell AFB, Texas.

15. The purpose of the ATN circuit is to support the worldwide network of solar optical, radio and ionospheric observing and forecasting sites located at both civilian and military observatories.

16. The objective of the facsimile systems is to transfer information quickly, accurately, and reliably.

17. The National Facsimile Network (WFX 1234) is considered the basic weather graphics network.

18. The FOFAX GF 10206, 7, and 8 transmit selected satellite charts.

19. The Strategic Facsimile Network (AFX 109).

20. Upon receipt of facsimile charts, most stations require the person who receives the chart to evaluate its quality. The evaluation scale is 3, 2, and 1. (Excellent, good, and unacceptable standard.)

21. The requirements fall into four major categories:
    a. Meteorological data routinely available in the worldwide weather communications complex, the sources of which are described in the various military and civil communications publications.
    b. Meteorological products prepared by central/centers that do not fall in the category described above.
    c. Meteorological data and products specifically tailored to support military command/control systems.
    d. Meteorological packages containing weather information designed for use in supporting contingency operations.

22. AWS units are responsible for establishing and registering their weather data requirements (through command channels) with the appropriate AWS theatre agency.

23. There are three categories for submission of data requirements. They are routine, urgent, and immediate.

24. Routine.

25. AWS Form 23, MANAM Action Request.

26. Urgent.

27. The immediate category is used when the data support is required to meet tactical action or situation gravely affecting the national security.

28. For direct support under immediate conditions use the most expeditious means available.

29. AWS theater MANAM agencies are responsible within their respective areas of interest.

30. Annually, prior to 15 January.

Section 6

1. Volume I of AWSM 105–2 series applies to all units regardless of location.

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2. AWSM 105–2, Volume I, deals with communications policies and responsibilities of AWS units.

3. AWSM 105–2, Volume I.

4. By appending a number following the data designator and geographical area.

5. The station or center which compiled the message for transmission.

6. The primary reason is that messages have lost their operational value due to time decay.

7. Transmit "NIL" and follow with an "RTD" message as soon as available.

8. The message is transmitted four times daily and may contain as many as 300 groups.

9. The term "half-duplex circuit" means capable of sending and receiving but not at the same time.

10. The network control stations (NCSs) are responsible for enforcing circuit discipline.

11. A communications operations report is sent to the station concerned. This report provides sufficient data to analyze each phase of operation.

12. AFSCR 105–2, Volume II.

13. If your communications manuals and regulations are not *current* and *readable*, they are of no value to anyone for reference.

14. The abbreviation MANAM means manual amendments.

15. When issued, they will indicate the chronological MANAM numbers through which the change is current.

16. AFR 5–31, *Publications Libraries and Operational Publications Sets.*

17. With less than 7 LETTERS, the tape does not feed through the transmitter far enough to transmit the entire text. If more than 7 LETTERS are used, unnecessary impulses are transmitted.

18. T-time tapes have a 2-LF 7-LTR tail; H-time tapes have just 7 LTRS.

19. The lead station in the collective.

20. All scheduled observation transmission which you miss must be transmitted as routine delayed weather (RTD) in the first T-time scan possible. RTDs must contain the original MANOP heading time of the bulletin to which they refer.

21. Unless a later transmitted observation corrects the element in error, you must send a corrected weather message.

22. AWSM 105–2, Volume I.

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23. In each TYPNO(OK) message, include the circuit number, a description of the trouble, and the MANOP heading of the last message that was received prior to service interruption or the first message received after the restoration of service.

24. KAWN considers any discrepancy that interferes with the orderly flow of traffic to be a major violation, whereas a minor violation, does not affect the orderly flow of traffic but may cause the unwarranted use of service time.

25. This would result in the unnecessary consumption of circuit time due to the extra impulses that would be transmitted before the actual text of the message entered the transmitter. This is classified as a minor discrepancy by KAWN.

26. 10.

Section 7

1. Weather editors are assigned to major and minor communications centers to provide the technical knowledge of weather operations and weather message bulletin composition.

2. ADWS means Automatic Digital Weather Switch.

3. Civil international circuits, AFCS circuits, and radio weather intercepts.

4. They provide weather data to AWS units in the local area and to the servicing ADWS center.

5. The primary tools of a weather editor are civilian and military communications manuals and publications.

6. AWSM 105–2, Volume II.

7. Only the weather editor can identify broadcasts that have gone astray or recognize good weather data. He also must note and report changes in broadcast content to higher headquarters as they occur.

8. Message interpretation means to identify types of data contained in a weather message, the stations contained in the message, and the geographical area and time frame.

9. Message preparation is the construction of weather bulletins under prescribed headings as directed by AWSM 105–2, Volume II.

10. An alternate bulletin is one filed by an editing section that will serve as an acceptable substitute to replace a missing bulletin.

11. Message withdrawal is removal of obsolete or superceded weather data from weather circuitry.

12. URGENT or IMMEDIATE requests for data are messages received by an editing section, from AWS data users, for weather data required to support other than normal operational requirements.

13. Special logs must be maintained on URGENT and IMMEDIATE request for data to assure that all editors and the section supervisor are aware of the requests so that maximum effort is exerted to satisfy the request.

14. The weather editor.

15. Primary duty of an editor assigned to an automated editing section is to identify and correct message formats, and reprocess weather information unrecognizable by the computer.

16. Sources of data for the manual editing sections use in weather message preparation are "blind" radio weather broadcasts; automatic editing sections have these broadcasts plus military and civilian sources of data.

17. A "strays" position is a monitor position located in the automated editing section that receives all rejects from the computer.

18. The MDL is a computer program that controls the distribution of all bulletins scheduled through the ADWS.

19. The STALIB is a computer program that controls the routing of each weather station report that comes into or goes out of your ADWS.

20. A "forget" routine permits the editor to remove rejected, unidentifiable data that cannot be utilized or interpreted by the computer system.

21. A "STATS" routine provides a comparison between the data amounts currently being received and what is normally received.

CHAPTER 3

Sections 8 and 9

1. Real Time Operating System (RTOS).

2. The data base.

3. The batch programs.

4. A program was devised to extract batched (processed) data from the primary system, put it on magnetic tape and read the data into the other three systems to update their data base.

5. "Program files" actually instruct the computer to recognize and respond to various key-in functions.

6. Files for scheduled weather production programs.

7. The RTOS program.

8. Computer flight plans for any part of the world desired.

9. The RTOS program *must* be running in the computer or the RFMCFP program simply will not run.

10. The RFMCFP program automatically terminates.

11. With a key-in.

12. The (RTR) program is essentially a net watch which sorts data as it is received in the computer and automatically routes it to SAC support units.

13. Data is compiled by forecasters in the Global Weathers Severe Weather Section.

14. Part two of the SWX program puts together the actual severe weather bulletins that are transmitted to the field.

15. System 3.

16. The RTOS programs will not allow access to the remote receiving devices from logical System 4.

17. Yes, through a special computer program called TPEMKR.

18. No, some of its output includes AWN transmission tapes, some System 1 transmission tapes, and weather programs which provide products for the System 4 high-speed printer.

19. System 4.

20. They must be started by reading a program card deck into the system through a card reader.

21. The operator control console.

22. The console operator.

23. Monitoring the console printer.

24. The tape librarian.

25. Dirty and/or damaged magnetic tapes can, and have, caused delays in scheduled weather production programs.

26. The systems duty officer (SDO) provides technical assistance to the computer operating staff.

27. The duty team chief.

28. The system's checklists.

STOP– 1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.

2. USE NUMBER 1 OR NUMBER 2 PENCIL.

25251 03 26

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE

Carefully read the following:

DO'S:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, take action to return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that numerical sequence on answer sheet alternates across from column to column.
3. Use a medium sharp #1 or #2 black lead pencil for marking answer sheet.
4. Circle the correct answer in this test booklet. After you are sure of your answers, transfer them to the answer sheet. If you *have* to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if at all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If *mandatorily* enrolled student, process questions or comments through your unit trainer or OJT supervisor.
   If *voluntarily* enrolled student, send questions or comments to ECI on ECI Form 17.

DON'TS:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #1 or #2 black lead pencil.

NOTE: TEXT PAGE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE. In parenthesis after each item number on the VRE is the *Text Page Number* where the answer to that item can be located. When answering the items on the VRE, refer to the *Text Pages* indicated by these *Numbers*. The VRE results will be sent to you on a postcard which will list the *actual VRE items you missed*. Go to the VRE booklet and locate the *Text Page Numbers* for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

Multiple Choice

1. (001) What publication describes the various synoptic codes and the encoding of the individual elements?

   a. AWSM 105-22.
   b. AWSM 105-24.
   c. FMH1.
   d. FMH2.

2. (002) The first digit (N) of the sky cover and wind group (Nddff) represents the

   a. total sky cover in oktas.
   b. total sky cover in tenths.
   c. lowest layer amount of sky cover in oktas.
   d. lowest layer amount of sky cover in tenths.

3. (003) If more than one weather code type occurs, which code number for "ww" in the "VVwwW" code group has priority over numbers 20 through 49?

   a. 15.
   b. 17.
   c. 19.
   d. 21.

4. (003) In synoptic code, the pressure is encoded to the nearest

   a. 1/100 of an inch.
   b. 1/10 of an inch.
   c. 1/10 of a millibar.
   d. 1/100 of a millibar.

5. (004) The first digit of the cloud code group (N_h) in synoptic code represents the total amount of

   a. low clouds and middle clouds present only.
   b. low clouds present, if none, then the total amount of middle clouds present only.
   c. low clouds present, if none, then the total amount of middle clouds and high clouds present.
   d. low clouds, middle clouds, and high clouds present.

6. (005) The synoptic code supplementary group that contains a precipitation group of 2.37 inches is

   a. $737R_t$ TWO.
   b. $737R_tS$.
   c. $737R_tS$ TWO.
   d. 737 TWO.

7. (005) The cloud layer group ($8N_sCh_sh_s$) in land synoptic code should be reported by

   a. Region II.
   b. Regions III and IV.
   c. Regions IV and V.
   d. Regions V and VI.

8. (006) The land synoptic code group ($2R_{24}R_{24}R_{24}R_{24}$) for Region IV that contains a precipitation group of 10.01 inches is

   a. 21001.
   b. 21007.
   c. 20001 ten.
   d. 20101 ten.

9. (007) When looking at a synoptic code, what is the *first* clue that indicates that you are looking at the ship synoptic code?

   a. A latitude and longitude group.
   b. A 99 group.
   c. The identifier "SHIP" or the actual ship name.
   d. The wave height group.

10. (007-008) When plotting the ship synoptic code ($YYGGi_w$), the group (i_w) is encoded "O" or "1" if the

    a. waves are less than 1 foot.
    b. winds are in meters per second.
    c. winds are in knots.
    d. winds are mph.

11. (008) The ship synoptic code ($1T_wT_wT_w$) group that contains the sea surface temperature of $-3.1°$ C. is

    a. 1531.
    b. 1031.
    c. 1003.
    d. 1031 minus.

12. (008-009) What code format is *generally* used in the continental United States to plot local area surface charts?

    a. METAR.
    b. Aero.
    c. AIREP.
    d. Airways.

13. (009) Generally, each weather station plots a minimum of how many LASC per day (24-hour period)?

    a. 1.
    b. 2.
    c. 3.
    d. 6.

14. (009) The type of chart that should be plotted during severe weather is the

    a. LASC.
    b. LAWC.
    c. hodograph.
    d Skew-T.

15. (012) The main difference between an LAWC and LASC chart is that an

    a. LAWC is used for a more complete analysis than an LASC.
    b. LASC is used for a more complete analysis than an LAWC.
    c. LAWC is used only for the severe weather program.
    d. LASC is used only for analysis of radar reports.

16. (012) If two pilot reports are received for the same location and the same phenomena, what plotting procedure should be followed?

    a. Plot both as received.
    b. Illustrate the second report.
    c. Plot the latest report only.
    d. Plot the first report only.

17. (015) What three items are required when plotting the significant parts of a radar report?

a. Type, tops, and phenomena.
b. Movement, size, and intensity.
c. Tops, movement, and type.
d. Intensity, type, and movement.

18. (015) On what chart do you normally plot a severe weather advisory?

a. LAWC.
b. Constant pressure chart.
c. LASC.
d. Upper air chart.

19. (016) The first transmission of the radiosonde code provides

a. Parts A and C of the radiosonde code.
b. sounding data for mandatory levels only.
c. sounding data for regional distribution only.
d. sounding data for all levels occurring at and below 100 mb.

20. (017) If the radiosonde balloon release is made at 1120, what coded time would you report?

a. 1100.
b. 1120.
c. 1150.
d. 1200.

21. (018) A characteristic of radiosonde code surface data is that the

a. Part A surface indicator is 99.
b. surface winds are found in Part B.
c. indicator 00 indicates surface data only.
d. surface pressure is reported in tens of millibars.

22. (018) Which of the following is coded correctly to indicate the 850-mb standard isobaric level?

a. 00850.
b. 08500.
c. 40850.
d. 85491.

23. (018-019) Refer to Table 11. What temperature and dewpoint is represented by a temperature group (TTT_aDD) of 12372 when decoded from the radiosonde code?

a. Temperature 12.3, dewpoint 72.
b. Temperature 12.3, dewpoint 7.2.
c. Temperature -12.3, dewpoint 22.
d. Temperature –12.3, dewpoint 2.2.

24. (019) Maximum wind is included in Part A of a radiosonde report when it occurs at or below

a. 500 mb.
b. 250 mb.
c. 100 mb.
d. 50 mb.

25. (020) Significant levels reported in Part B of the radiosonde code are *not* selected for pressures below

a. 500 mb.
b. 200 mb.
c. 100 mb.
d. 50 mb.

26. (021) In the radiosonde code, all mandatory levels whose pressure is above 100 mb are reported in

a. Part A.
b. Part B.
c. Part C.
d. Part D.

27. (021) Plain language data always follows the indicator

a. 51515.
b. 55555.
c. 59999.
d. 95955.

28. (022) The location of a ship at 48.6° north latitude and 45.7° west longitude should be encoded in a TEMP SHIP report as

a. 99486 70457 14985.
b. 99486 10457 14985.
c. 99457 70486 14958.
d. 99457 10486 14958.

29. (022) Upper wind data are normally available only at which of the following times?

a. 0300Z and 0600Z.
b. 0300Z, 0900Z, 1200Z, 1800Z.
c. 0000Z, 0600Z, 1200Z, 1800Z.
d. 0000Z, 0300Z, 0600Z, 0900Z, 1200Z.

30. (024) Mandatory levels for upper wind code are transmitted in

a. Parts A and B.
b. Parts A and C.
c. Parts C and D.
d. Parts B and C.

31. (025) If the maximum wind in Part A for upper wind code ($H_mH_mH_mH_m$) is encoded as 1200, what is the actual height?

a. 12,000 feet.
b. 24,000 feet.
c. 36,000 feet.
d. 48,000 feet.

32. (025-026) The darkened circle plotted on a constant pressure chart correlates with the plot whose depression is

a. 5° or less.
b. 10° or less.
c. 5° or more.
d. 10° or more.

33. (027) What color scheme shows the sequence in which sounding should be plotted on a Skew-T chart?

a. Black, blue, and red.
b. Blue, black, and red.
c. Blue, red, and black.
d. Red, blue, and black.

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34. (028) Which of the following aircraft codes is used to report weather parameters on nonweather flights?

a. AIREP.
b. COMBAR.
c. RECCO.
d. PIREP.

35. (028) AWS aircraft using RECCO code should report when dewpoint is available by coding i_u as

a. 0.
b. 1.
c. 2.
d. 4.

36. (029) If the true airspeed of the aircraft in RECCO code is encoded in the remarks section, how would a true airspeed of 360 knots be encoded?

a. 36.
b. 360.
c. 360 kt.
d. TAS360.

37. (029) In RECCO code, what coded value of "j" in the group (mjHHH) represents a height of 300 mb?

a. 3.
b. 4.
c. 5.
d. 6.

38. (030) When the radio altimeter is inoperative and "9" is encoded (RECCO code) for "j," the "HHH" will be coded as

a. ///.
b. 999.
c. MMM.
d. 013.

39. (030) In RECCO code, a wind from 270° at 164 knots is coded as

a. 27164.
b. 47764.
c. 2764 ONE.
d. 27064 ONE.

40. (031) The "7" indicator group in RECCO code is *primarily* used to report

a. significant weather on or off course.
b. icing information.
c. radar echo information.
d. the state of the sea swells.

41. (032) Which of the following forms is used to record COMBAR code?

a. AWS Form 93.
b. AWS Form 81.
c. MAC Form 80.
d. MAC Form 65.

42. (033) In COMBAR code, the letter designator which indicates an overcast sky cover condition is

a. U.
b. O.
c. V.
d. C.

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43. (033) When the plotting of COMBAR reports is required, the reports are normally plotted on

a. local area charts.
b. upper air charts.
c. land synoptic charts.
d. ship synoptic charts.

44. (035) In AIREP code, the four groups that are deleted prior to transmission over teletype are

a. Current Position Data.
b. Next Position Information.
c. Midpoint Information.
d. Current Weather Data.

45. (035) AIREP code is usually plotted on

a. an LAWC.
b. an LASC.
c. a Skew-T chart.
d. a constant pressure chart.

46. (036) What system is used for long-line dissemination of weather data between military weather units?

a. Automatic collection-dissemination system.
b. National Weather Service System.
c. Federal Aviation Agency System.
d. Modernized Weather Teletypewriters Communications System.

47. (036) The mission of the USAF/DCS Weather Networks is to provide communication services for

a. AWS only.
b. DOD agencies only.
c. AWS and other DOD agencies only.
d. AWS, DOD agencies, and FAA agencies.

48. (037) Which of the following capabilities does *not* apply to COMET III?

a. Receives forecasts.
b. Receives upper air data.
c. Transmits radar reports.
d. Receives synoptic code data.

49. (038) MWTCS consolidates the circuit control and relay functions for Services A and C into a single relay center located at the

a. Weather Message Switching Center (WMSC), Kansas City, Missouri.
b. Automated Weather Network (AWN), Relay Center, Carswell AFB, Texas.
c. Tinker Weather Relay Center (KWRF), Tinker AFB, Oklahoma.
d. Fleet Numerical Weather Facility (FNWF), Monterey, California.

50. (038) Which of the following networks is the *primary* circuit for collection of airways observations?

a. Service A.
b. Service B.
c. Service C.
d. Service D.

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51. (038-039) An ADWS (Automatic Digital Weather Switch) is *not* located in

a. Fuchu AS, Japan.
b. Clark AB, Philippines.
c. Carswell AFB, Texas.
d. NMC, Suitland, Maryland.

52. (039) The Solar Observing and Forecasting Network Organization from ADWS at Carswell AFB, Texas is

a. COMET I.
b. COMET II.
c. COMET III.
d. ASTRO/Geophysical Teletype Network (ATN).

53. (040) What is the basic objective of the Weather Facsimile Networks?

a. Transfer information quickly, accurately, and reliably.
b. Transfer information which is considered an extra copy of the original material.
c. Transmit a graphic product over electrical paths by dividing the image into extremely small round elements.
d. All of the above objectives.

54. (040-041) If the quality of a facsimile chart is below the acceptable AWS standard, the chart should be graded

a. 4.
b. 3.
c. 2.
d. 1.

55. (041) A category of priority under which data requirements can *not* be submitted is

a. an urgent request.
b. a routine request.
c. an immediate request.
d. a classified request.

56. (041) If a data request is necessary to meet normal mission changes, it would be sent under which priority?

a. Urgent.
b. Routine.
c. Immediate.
d Classified.

57. (042) Under what priority should a data requirement request be sent if the AWS unit was not given sufficient advance notice for routine action?

a. Urgent.
b. Routine.
c. Immediate.
d. Classified.

58. (042) If a data request is required to meet a tactical action or situation gravely affecting the national security, under what priority should the request be sent?

a. Urgent.
b. Routine.
c. Immediate.
d. Classified.

59. (059) The volume of communications manual AWSM 105-2 which applies to all units, regardless of location, is

a. I.
b. II.
c. III.
d. IV.

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60. (044) The primary reason that the network may withdraw a weather message from the circuit is that the

a. bulletin contains an improper format.
b. bulletin has too many typing errors.
c. message does not contain a MANOP heading.
d. message has lost its operational value due to time decay.

61. (044) The communications volume which contains the listing of weather messages is the

a. AWSM 105-2, Volume I.
b. AWSM 105-2, Volume II.
c. AFCSR 105-2, Volume I.
d. AFCSR 105-2, Volume II.

62. (046) The communications volume which provides general policies on weather message preparation is the

a. AWSM 105-2, Volume II.
b. AWSM 105-2, Volume I.
c. AFCSR 105-2, Volume II.
d. AFCSR 105-2, Volume I.

63. (047-048) How many typing characters are required for the leader and tail on an H-time tape?

a. 7 LTRS (leader) 10 LTRS (tail).
b. 10 LTRS (leader) 7 LTRS (tail).
c. 7 LTRS (leader) 2 LF 10 LTRS (tail).
d. 10 LTRS (leader) 2 LF 7 LTRS (tail).

64. (048) During T-time special collection, the data identifier is supplied by the

a. net control station.
b. weather relay facility.
c. collective's lead station.
d. individual sending stations.

65. (048) RTDs are messages transmitted during

a. T-time general scan collection.
b. T-time special collection.
c. H-time scan.
d. H-time.

66. (050) Who has the initial responsibility in grading and evaluating facsimile product quality?

a. KAWN.
b. AWS unit.
c. Local AFCS units.
d. Communications management office.

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67. (051) What is the primary source of weather data available to an editor assigned to a manual editing function?

a. Other AFCS relay centers.
b. USAF radio weather broadcasts.
c. "Blind" radio WMO weather broadcasts.
d. USAF and friendly military weather broadcasts.

68. (052) What steps are used in message interpretation?

a. Identifying the data type and changing the received heading to the prescribed heading.
b. Identifying the data type, the source of the data, and the AFCS operator that copied the data.
c. Identifying the date-time group and stations reporting and assembling one-line observations into multilined messages.
d. Identifying the FM data type, the date-time group of the data, the stations reporting, and the geographical area the bulletin covers.

69. (052) Data received from "blind" intercepts are usually

a. interpreted by AFCS personnel.
b. clear, correct weather bulletins that need little changing.
c. garbled, incorrectly formated, and in a generally unsuitable condition for interpretation by anyone but a skilled weather editor.
d. garbled, incorrectly formated messages that may be easily corrected by the editor with the help of AFCS communicators.

70. (052) Message preparation at a manual editing section is the procedure through which the weather editor

a. decides what type data he has and what to do with it.
b. decides what type data he has and constructs weather bulletins under prescribed FM type headings.
c. constructs weather bulletins under prescribed FM type headings and transmits them to the users.
d. constructs weather bulletins under prescribed FM type headings for transmission by AFCS.

71. (052) Followup action on messages prepared by the editor assures that the message has been

a. transmitted.
b. identified.
c. properly logged.
d. put in the correct format.

72. (052-053) Message withdrawal notices provide for the removal of

a. superseded or obsolete weather messages.
b. all weather messages from a circuit that is backlogged due to circuit outage.
c. all data 3 hours old for the transmission of more current data.
d. certain lengthy messages from backlogged circuits to assure transmission of shorter messages.

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73. (053) An URGENT or IMMEDIATE request for data is a request for data

a. not available and required by AFCS for transmission now.
b. by AWS units to support other than normal operational requirements.
c. originated by the editor to meet his prescribed bulletin requirements.
d. originated by the editor because all of his data sources have gone off the air.

74. (053) The primary duty of an editor assigned to an Automatic Digital Weather Switch Center (ADWS) is

a. identical to that of a manual weather editor.
b. to operate the computer system.
c. to correct message formats and remove data from the system that is unrecognizable by the computer.
d. to correct message formats and reprocess weather information which is not recognizable by the computer.

75. (054) The STALIB computer program

a. controls each and every weather reporting station that comes into or goes out of the ADWS.
b. routes and distributes all messages that come into or go out of the ADWS.
c. aids the editor in bulletin preparation within the ADWS.
d. is used in determining where data should be sent.

76. (054) The editor must initially correct and reprocess data received from the computer

a. immediately.
b. as soon as possible, but with no time limits established.
c. within 3 minutes.
d. within 5 minutes.

77. (054) "Stats" are statistical routines that are

a. issued by the editor for computer programming.
b. used by AWS to determine the amount of data transmitted.
c. used by AFCS to compare current data transmission with normal flow.
d. issued by the computer to compare data amounts currently being received with what is normally received.

78. (056) What program makes it possible for the primary system to receive live data, process it, and transmit finished products to the field?

a. RFMCFP.
b. SWX.
c. RTR.
d. RTOS.

79. (056) Raw data received at AFGWC

a. are of immediate value for use in scheduled weather program.
b. are stored on one of the mass storage drums until needed by scheduled weather programs.
c. cannot be used for weather programs until they are processed and put into the data base.
d. are temporarily stored on drums and then removed.

80. (058) Which program will put "program files" into the computer for scheduled weather production runs?

a. RFMCFP.
b. RUNSTREAM.
c. RTOS.
d. BATCH.

81. (058) The RFMCFP program was developed to

a. produce computer flight plans to all parts of the world.
b. produce computer flight plans only within the continental United States.
c. provide support to the Severe Weather Forecasting Section.
d. provide finished weather products for SAC support units.

82. (059) The Severe Weather (SWX) programs are normally started on the primary computer system by

a. a remote device, known as a DCT 2000, in the Severe Weather Section.
b. a remote device, known as a KSR, in the Severe Weather Section.
c. the console operator with a key-in.
d. reading an SWX program card deck into the computer.

83. (059) The *primary* reason the RTOS may be described as the lifeblood of the primary computer is because RTOS

a. transmits weather production programs.
b. generates weather production programs.
c. selects data for direct transmission to users.
d. programs the finished forecast products.

84. (060) Which computer system in AFGWC produces all the classified data?

a. System 4.
b. System 3.
c. System 2.
d. System 1.

85. (060) The bulk of System 4's daily output is

a. AWN transmission tapes.
b. printed operational output for AFGWC forecasters.
c. generated backing up System 1.
d. generated from the development and testing phase of computer operations.

86. (061) Which AFGWC system generates forecasts fields to be put on magnetic tapes and read into the other systems?

a. System 4.
b. System 3.
c. System 2.
d. System 1.

87. (061) The component by which the functions of a system in AFGWC is controlled is the

a. DSR.
b. servo unit.
c. card reader.
d. operator control console.

88. (061-062) To which remote device is the bulk of System 1's transmissions made?

a. KSR.
b. DCT 2000.
c. Card punch.
d. High-speed printer.

89. (062) It is a task of the console operator to

a. mount and dismount magnetic tapes.
b. sort and deliver output from the HSP.
c. start scheduled weather programs.
d. maintain the computer outage log.

90. (063) In a properly manned computer system, which of three operators is assigned the task of sorting and delivering operational weather data to forecasters in the AFGWC?

a. The tape handler.
b. The printer operator.
c. The console operator.
d. All three operators share in this responsibility.

91. (063) "Purging" a tape means that the tape is

a. physically destroyed.
b. filed numerically.
c. returned to a work status.
d. assigned to a development job.

92. (064) The overall responsibility for the actual operation of the computers and the quality of the output belongs to the

a. SDO.
b. team chief.
c. senior operator.
d. assistant team chief.

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25251 03 S01 7204

SUPPLEMENTARY MATERIAL

CDC 25251

WEATHER OBSERVER

Volume 3

Foldouts 1 through 9

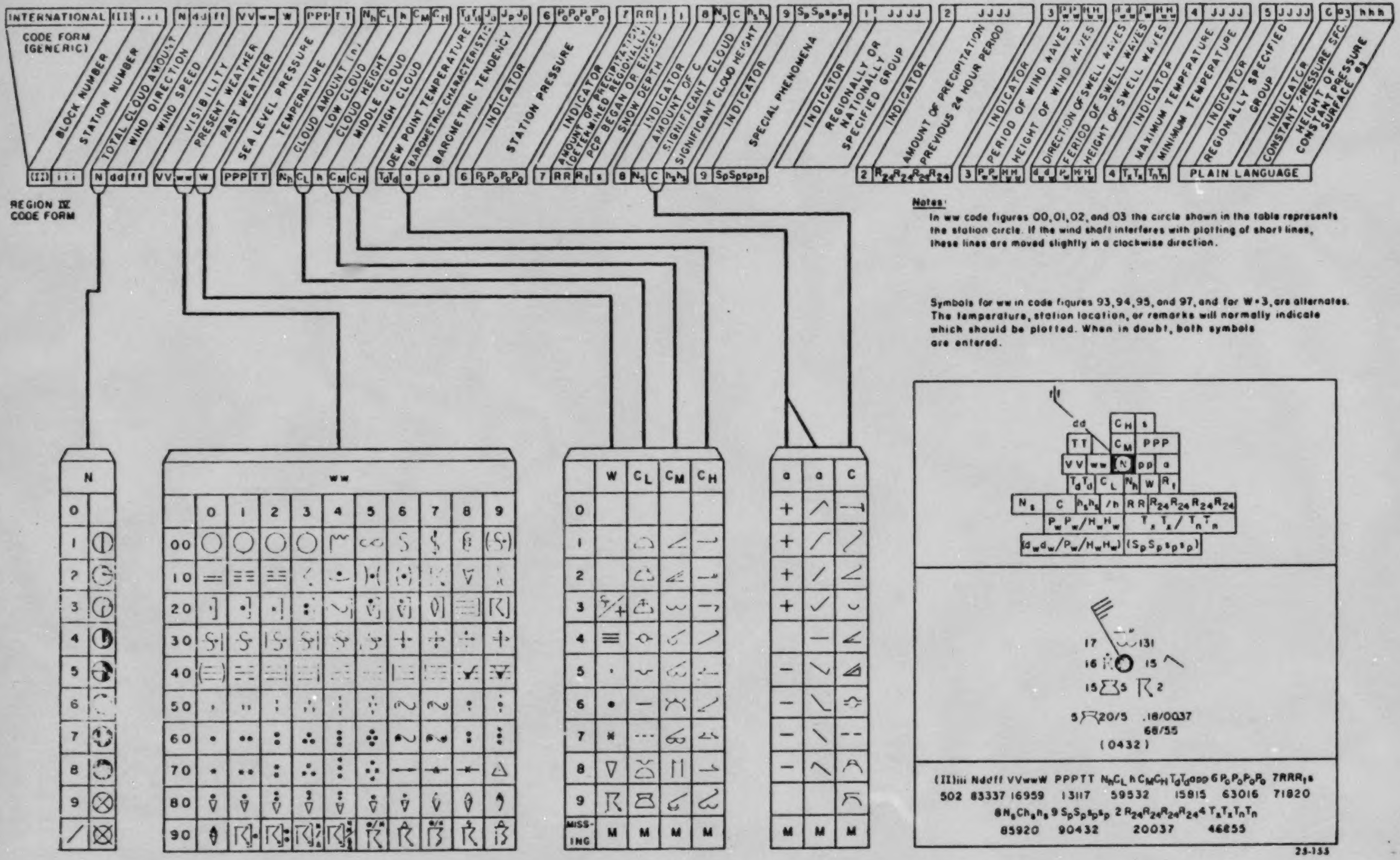
AU GAFS,ALA.(731154)1900

15-1

Extension Course Institute

Air University

PLOTTING GUIDE, SYNOPTIC CODE


INTERNATIONAL
CODE FORM (GENERIC)
BLOCK NUMBER
STATION NUMBER
TOTAL CLOUD AMOUNT
WIND DIRECTION
WIND SPEED
VISIBILITY
PRESENT WEATHER
PAST WEATHER
SEA LEVEL PRESSURE
TEMPERATURE
CLOUD AMOUNT (h)
LOW CLOUD
CLOUD HEIGHT
MIDDLE CLOUD
HIGH CLOUD
DEW POINT TEMPERATURE
BAROMETRIC CHARACTERISTIC
BAROMETRIC TENDENCY
INDICATOR
STATION PRESSURE
INDICATOR
AMOUNT OF PRECIPITATION (DETERMINED REGIONALLY)
PCP BEGAN OR ENDED
SNOW DEPTH
INDICATOR
AMOUNT OF C
SIGNIFICANT CLOUD
SIGNIFICANT CLOUD HEIGHT
INDICATOR
SPECIAL PHENOMENA
INDICATOR
REGIONALLY OR NATIONALLY SPECIFIED GROUP
INDICATOR
AMOUNT OF PRECIPITATION PREVIOUS 24 HOUR PERIOD
INDICATOR
PERIOD OF WIND WAVES
HEIGHT OF WIND WAVES
DIRECTION OF SWELL WAVES
PERIOD OF SWELL WAVES
HEIGHT OF SWELL WAVES
INDICATOR
MAXIMUM TEMPERATURE
MINIMUM TEMPERATURE
INDICATOR
REGIONALLY SPECIFIED GROUP
INDICATOR
CONSTANT PRESSURE SFC.
HEIGHT OF CONSTANT PRESSURE SURFACE
PLAIN LANGUAGE
REGION IV CODE FORM
N
ww
W
CL
CM
CH
a
C
MISSING
M
00
10
20
30
40
50
60
70
80
90
23-155

Notes:

In ww code figures 00, 01, 02, and 03 the circle shown in the table represents the station circle. If the wind shaft interferes with plotting of short lines, these lines are moved slightly in a clockwise direction.

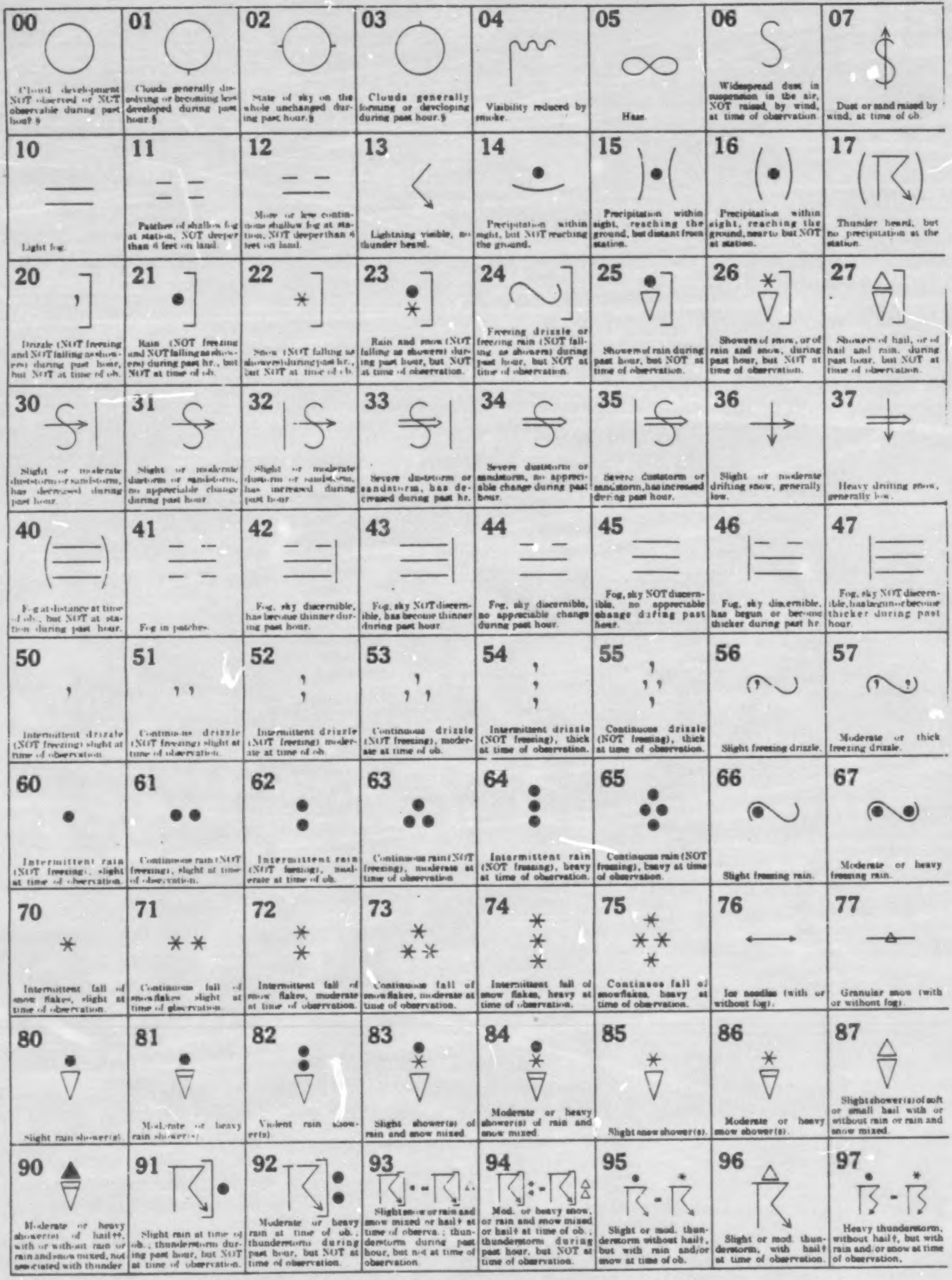
Symbols for ww in code figures 93, 94, 95, and 97, and for W = 3, are alternates. The temperature, station location, or remarks will normally indicate which should be plotted. When in doubt, both symbols are entered.

(II)iii Nddff VVwwW PPPTT $N_hC_L hC_MC_H T_dT_d app$ $6P_oP_oP_oP_o$ $7RRR_ts$
502 83337 16959 13117 59532 15815 63016 71820
$8N_sCh_sh_s$ $9S_pS_ps_ps_p$ $2R_{24}R_{24}R_{24}R_{24}$ $4T_xT_xT_nT_n$
85920 90432 20037 46855

Foldout 1

ww

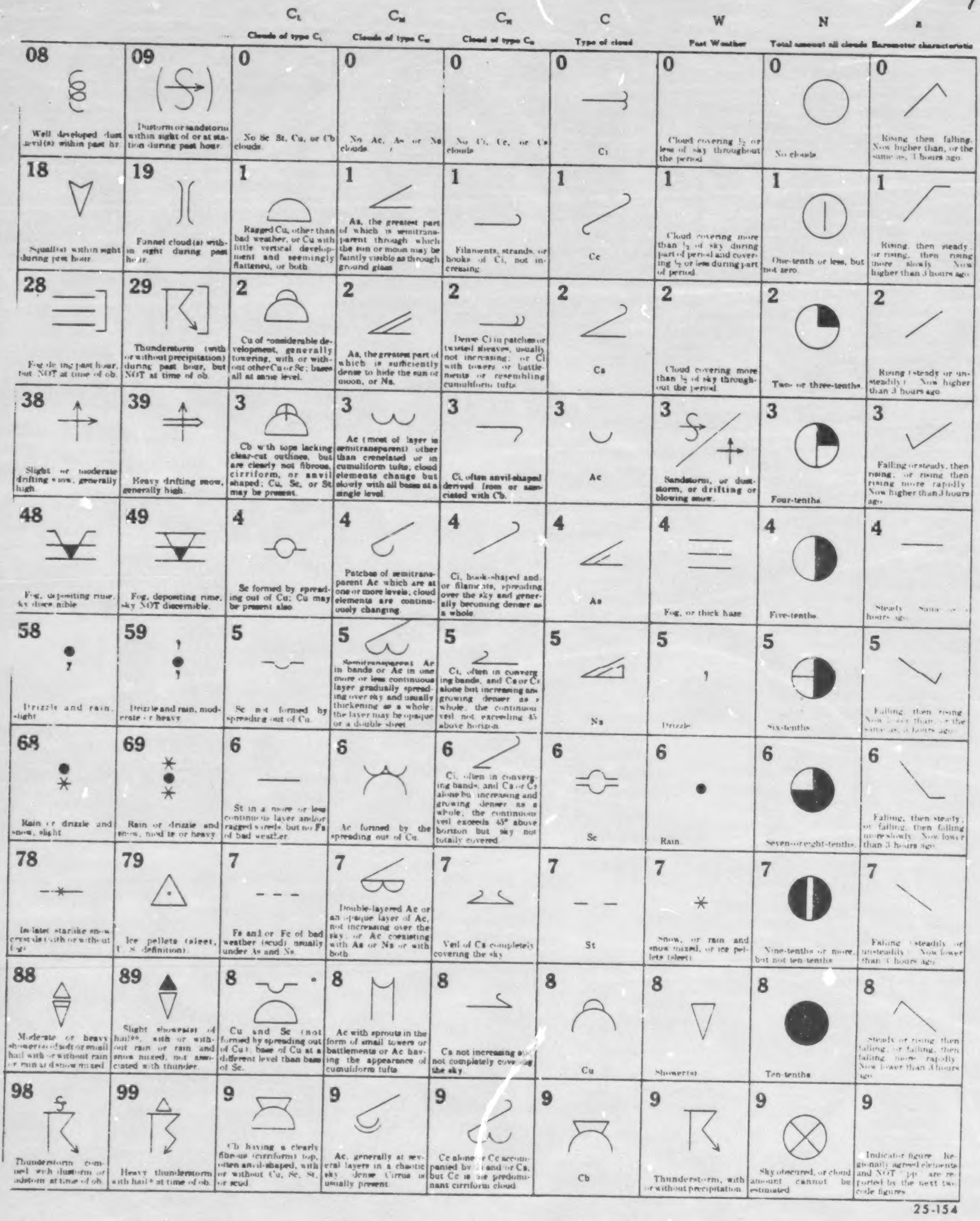
Present weather



00 Cloud development NOT observed or NOT observable during past hour.§	01 Clouds generally dissolving or becoming less developed during past hour.§	02 State of sky on the whole unchanged during past hour.§	03 Clouds generally forming or developing during past hour.§	04 Visibility reduced by smoke.	05 Haze.	06 Widespread dust in suspension in the air, NOT raised by wind, at time of observation.	07 Dust or sand raised by wind, at time of ob.
10 Light fog.	11 Patches of shallow fog at station, NOT deeper than 6 feet on land.	12 More or less continuous shallow fog at station, NOT deeper than 6 feet on land.	13 Lightning visible, no thunder heard.	14 Precipitation within sight, but NOT reaching the ground.	15 Precipitation within sight, reaching the ground, but distant from station.	16 Precipitation within sight, reaching the ground, near to but NOT at station.	17 Thunder heard, but no precipitation at the station.
20 Drizzle (NOT freezing and NOT falling as showers) during past hour, but NOT at time of ob.	21 Rain (NOT freezing and NOT falling as showers) during past hr., but NOT at time of ob.	22 Snow (NOT falling as showers) during past hr., but NOT at time of ob.	23 Rain and snow (NOT falling as showers) during past hour, but NOT at time of observation.	24 Freezing drizzle or freezing rain (NOT falling as showers) during past hour, but NOT at time of observation.	25 Showers of rain during past hour, but NOT at time of observation.	26 Showers of snow, or of rain and snow, during past hour, but NOT at time of observation.	27 Showers of hail, or of hail and rain, during past hour, but NOT at time of observation.
30 Slight or moderate duststorm or sandstorm, has decreased during past hour.	31 Slight or moderate duststorm or sandstorm, no appreciable change during past hour	32 Slight or moderate duststorm or sandstorm, has increased during past hour	33 Severe duststorm or sandstorm, has decreased during past hr.	34 Severe duststorm or sandstorm, no appreciable change during past hour.	35 Severe duststorm or sandstorm, has increased during past hour.	36 Slight or moderate drifting snow, generally low.	37 Heavy drifting snow, generally low.
40 Fog at distance at time of ob., but NOT at station during past hour.	41 Fog in patches.	42 Fog, sky discernible, has become thinner during past hour.	43 Fog, sky NOT discernible, has become thinner during past hour	44 Fog, sky discernible, no appreciable change during past hour.	45 Fog, sky NOT discernible, no appreciable change during past hour.	46 Fog, sky discernible, has begun or become thicker during past hr.	47 Fog, sky NOT discernible, has begun or become thicker during past hour.
50 Intermittent drizzle (NOT freezing) slight at time of observation.	51 Continuous drizzle (NOT freezing) slight at time of observation.	52 Intermittent drizzle (NOT freezing) moderate at time of ob.	53 Continuous drizzle (NOT freezing), moderate at time of ob.	54 Intermittent drizzle (NOT freezing), thick at time of observation.	55 Continuous drizzle (NOT freezing), thick at time of observation.	56 Slight freezing drizzle.	57 Moderate or thick freezing drizzle.
60 Intermittent rain (NOT freezing), slight at time of observation.	61 Continuous rain (NOT freezing), slight at time of observation.	62 Intermittent rain (NOT freezing), moderate at time of ob.	63 Continuous rain (NOT freezing), moderate at time of observation	64 Intermittent rain (NOT freezing), heavy at time of observation.	65 Continuous rain (NOT freezing), heavy at time of observation.	66 Slight freezing rain.	67 Moderate or heavy freezing rain.
70 Intermittent fall of snow flakes, slight at time of observation.	71 Continuous fall of snowflakes slight at time of observation.	72 Intermittent fall of snow flakes, moderate at time of observation.	73 Continuous fall of snowflakes, moderate at time of observation.	74 Intermittent fall of snow flakes, heavy at time of observation.	75 Continuous fall of snowflakes, heavy at time of observation.	76 Ice needles (with or without fog).	77 Granular snow (with or without fog).
80 Slight rain shower(s).	81 Moderate or heavy rain shower(s)	82 Violent rain shower(s)	83 Slight shower(s) of rain and snow mixed	84 Moderate or heavy shower(s) of rain and snow mixed.	85 Slight snow shower(s).	86 Moderate or heavy snow shower(s).	87 Slight shower(s) of soft or small hail with or without rain or rain and snow mixed.
90 Moderate or heavy shower(s) of hail††, with or without rain or rain and snow mixed, not associated with thunder	91 Slight rain at time of ob.; thunderstorm during past hour, but NOT at time of observation.	92 Moderate or heavy rain at time of ob.; thunderstorm during past hour, but NOT at time of observation.	93 Slight snow or rain and snow mixed or hail† at time of observa.; thunderstorm during past hour, but not at time of observation	94 Mod. or heavy snow, or rain and snow mixed or hail† at time of ob.; thunderstorm during past hour, but NOT at time of observation.	95 Slight or mod. thunderstorm without hail†, but with rain and/or snow at time of ob.	96 Slight or mod. thunderstorm, with hail† at time of observation.	97 Heavy thunderstorm, without hail†, but with rain and/or snow at time of observation.

Weather code figures and symbols

Foldout 2

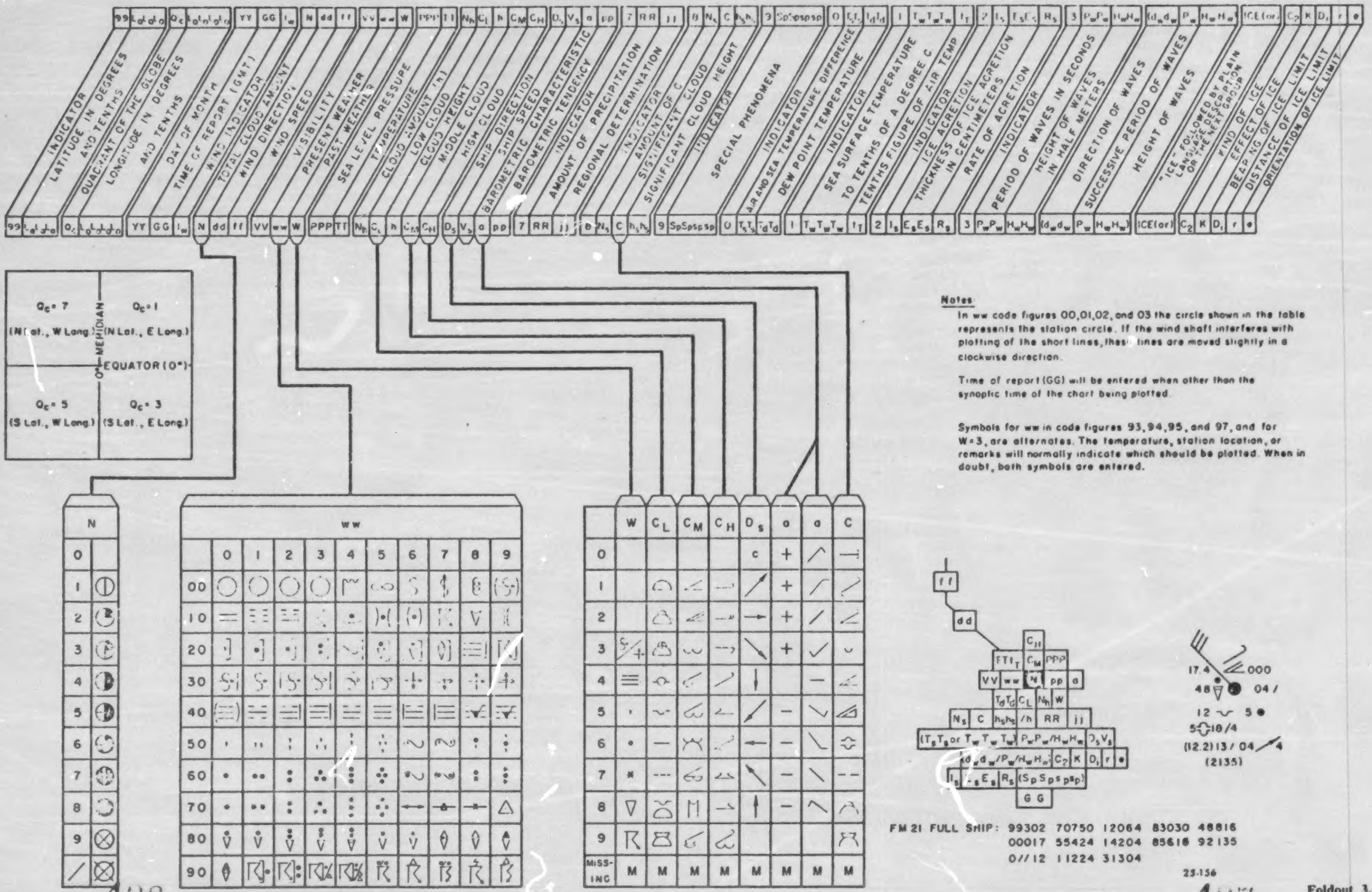


		C_L Clouds of type C_L	C_M Clouds of type C_M	C_H Cloud of type C_H	C Type of cloud	W Past Weather	N Total amount all clouds	a Barometer characteristic
08 Well developed dust devil(s) within past hr.	**09** Duststorm or sandstorm within sight of or at station during past hour.	**0** No Sc, St, Cu, or Cb clouds.	**0** No Ac, As or Ns clouds	**0** No Ci, Cc, or Cs clouds	**0** Ci	**0** Cloud covering ½ or less of sky throughout the period	**0** No clouds	**0** Rising then falling. Now higher than, or the same as, 3 hours ago.
18 Squall(s) within sight during past hour.	**19** Funnel cloud(s) within sight during past hour.	**1** Ragged Cu, other than bad weather, or Cu with little vertical development and seemingly flattened, or both	**1** As, the greatest part of which is semitransparent through which the sun or moon may be faintly visible as through ground glass	**1** Filaments, strands, or hooks of Ci, not increasing	**1** Cc	**1** Cloud covering more than ½ of sky during part of period and covering ½ or less during part of period.	**1** One-tenth or less, but not zero.	**1** Rising, then steady; or rising, then rising more slowly. Now higher than 3 hours ago.
28 Fog during past hour, but NOT at time of ob.	**29** Thunderstorm (with or without precipitation) during past hour, but NOT at time of ob.	**2** Cu of considerable development, generally towering, with or without other Cu or Sc; bases all at same level.	**2** As, the greatest part of which is sufficiently dense to hide the sun or moon, or Ns.	**2** Dense Ci in patches or twisted sheaves, usually not increasing; or Ci with towers or battlements or resembling cumuliform tufts	**2** Cs	**2** Cloud covering more than ½ of sky throughout the period.	**2** Two- or three-tenths.	**2** Rising (steady or unsteadily). Now higher than 3 hours ago.
38 Slight or moderate drifting snow, generally high.	**39** Heavy drifting snow, generally high.	**3** Cb with tops lacking clear-cut outlines, but are clearly not fibrous, cirriform, or anvil shaped; Cu, Sc, or St may be present.	**3** Ac (most of layer is semitransparent) other than crenelated or in cumuliform tufts, cloud elements change but slowly with all bases at a single level.	**3** Ci, often anvil-shaped derived from or associated with Cb.	**3** Ac	**3** Sandstorm, or duststorm, or drifting or blowing snow.	**3** Four-tenths.	**3** Falling or steady, then rising, or rising then rising more rapidly. Now higher than 3 hours ago.
48 Fog, depositing rime, sky discernible.	**49** Fog, depositing rime, sky NOT discernible.	**4** Sc formed by spreading out of Cu; Cu may be present also.	**4** Patches of semitransparent Ac which are at one or more levels; cloud elements are continuously changing.	**4** Ci, hook-shaped and/or filaments, spreading over the sky and generally becoming denser as a whole.	**4** As	**4** Fog, or thick haze	**4** Five-tenths.	**4** Steady. Same as 3 hours ago.
58 Drizzle and rain, slight	**59** Drizzle and rain, moderate or heavy	**5** Sc not formed by spreading out of Cu.	**5** Semitransparent Ac in bands or Ac in one more or less continuous layer gradually spreading over sky and usually thickening as a whole; the layer may be opaque or a double sheet	**5** Ci, often in converging bands, and Cs or Cs alone but increasing and growing denser as a whole, the continuous veil not exceeding 45° above horizon.	**5** Ns	**5** Drizzle	**5** Six-tenths	**5** Falling, then rising. Now lower than, or the same as, 3 hours ago.
68 Rain or drizzle and snow, slight	**69** Rain or drizzle and snow, moderate or heavy	**6** St in a more or less continuous layer and/or ragged shreds, but no Fs of bad weather.	**6** Ac formed by the spreading out of Cu.	**6** Ci, often in converging bands, and Cs or Cs alone but increasing and growing denser as a whole, the continuous veil exceeds 45° above horizon but sky not totally covered	**6** Sc	**6** Rain.	**6** Seven-or-eight-tenths.	**6** Falling, then steady, or falling, then falling more slowly. Now lower than 3 hours ago.
78 Isolated starlike snow crystals (with or without fog)	**79** Ice pellets (sleet, U. S. definition).	**7** Fs and/or Fc of bad weather (scud) usually under As and Ns.	**7** Double-layered Ac or an opaque layer of Ac, not increasing over the sky, or Ac coexisting with As or Ns or with both.	**7** Veil of Cs completely covering the sky	**7** St	**7** Snow, or rain and snow mixed, or ice pellets (sleet)	**7** Nine-tenths or more, but not ten-tenths	**7** Falling (steadily or unsteadily). Now lower than 3 hours ago.
88 Moderate or heavy shower(s) of soft or small hail with or without rain or rain and snow mixed.	**89** Slight shower(s) of hail**, with or without rain or rain and snow mixed, not associated with thunder.	**8** Cu and Sc (not formed by spreading out of Cu), base of Cu at a different level than base of Sc.	**8** Ac with sprouts in the form of small towers or battlements or Ac having the appearance of cumuliform tufts	**8** Cs not increasing and not completely covering the sky.	**8** Cu	**8** Shower(s)	**8** Ten-tenths	**8** Steady or rising, then falling, or falling, then falling more rapidly. Now lower than 3 hours ago.
98 Thunderstorm combined with duststorm or sandstorm at time of ob.	**99** Heavy thunderstorm with hail* at time of ob.	**9** Cb having a clearly fibrous (cirriform) top, often anvil-shaped, with or without Cu, Sc, St, or scud	**9** Ac, generally at several layers in a chaotic sky; dense Cirrus is usually present.	**9** Cc alone or Cc accompanied by Ci and/or Cs, but Cc is the predominant cirriform cloud	**9** Cb	**9** Thunderstorm, with or without precipitation.	**9** Sky obscured, or cloud amount cannot be estimated	**9** Indicator figure. Regionally agreed elements and NOT "ppp" are reported by the next two code figures.

25-154

Foldout 2. Weather code figures and symbols.

PLOTTING GUIDE, SHIP SYNOPTIC CODE


INDICATOR
LATITUDE IN DEGREES AND TENTHS
QUADRANT OF THE GLOBE
LONGITUDE IN DEGREES AND TENTHS
DAY OF MONTH
TIME OF REPORT (GMT)
WIND INDICATOR
TOTAL CLOUD AMOUNT
WIND DIRECTION
WIND SPEED
VISIBILITY
PRESENT WEATHER
PAST WEATHER
SEA LEVEL PRESSURE
TEMPERATURE
CLOUD AMOUNT (h)
LOW CLOUD
CLOUD HEIGHT
MIDDLE CLOUD
HIGH CLOUD
SHIP DIRECTION
SHIP SPEED
BAROMETRIC CHARACTERISTIC
BAROMETRIC TENDENCY
INDICATOR
AMOUNT OF PRECIPITATION
REGIONAL DETERMINATION
INDICATOR
AMOUNT OF C
SIGNIFICANT CLOUD
SIGNIFICANT CLOUD HEIGHT
INDICATOR
SPECIAL PHENOMENA
INDICATOR
AIR AND SEA TEMPERATURE DIFFERENCE
DEW POINT TEMPERATURE
INDICATOR
SEA SURFACE TEMPERATURE TO TENTHS OF A DEGREE C
TENTHS FIGURE OF AIR TEMP
INDICATOR
ICE ACRETION
THICKNESS OF ICE ACRETION IN CENTIMETERS
RATE OF ACRETION
INDICATOR
PERIOD OF WAVES IN SECONDS
HEIGHT OF WAVES IN HALF METERS
DIRECTION OF WAVES
SUCCESSIVE PERIOD OF WAVES
HEIGHT OF WAVES
"ICE" FOLLOWED BY PLAIN LANGUAGE DESCRIPTION OR THE NEXT GROUP
KIND OF ICE
EFFECT OF ICE
BEARING OF ICE LIMIT
DISTANCE OF ICE LIMIT
ORIENTATION OF ICE LIMIT
Qc = 7 (N Lat., W Long.)
Qc = 1 (N Lat., E Long.)
EQUATOR (0°)
0°—MERIDIAN
Qc = 5 (S Lat., W Long.)
Qc = 3 (S Lat., E Long.)
N
ww
W
CL
CM
CH
Ds
a
a
C
MISSING
M
ff
dd
17.4
000
48
04/
12
5
5
10/4
(12.2)13/04
4
(2135)

Notes:

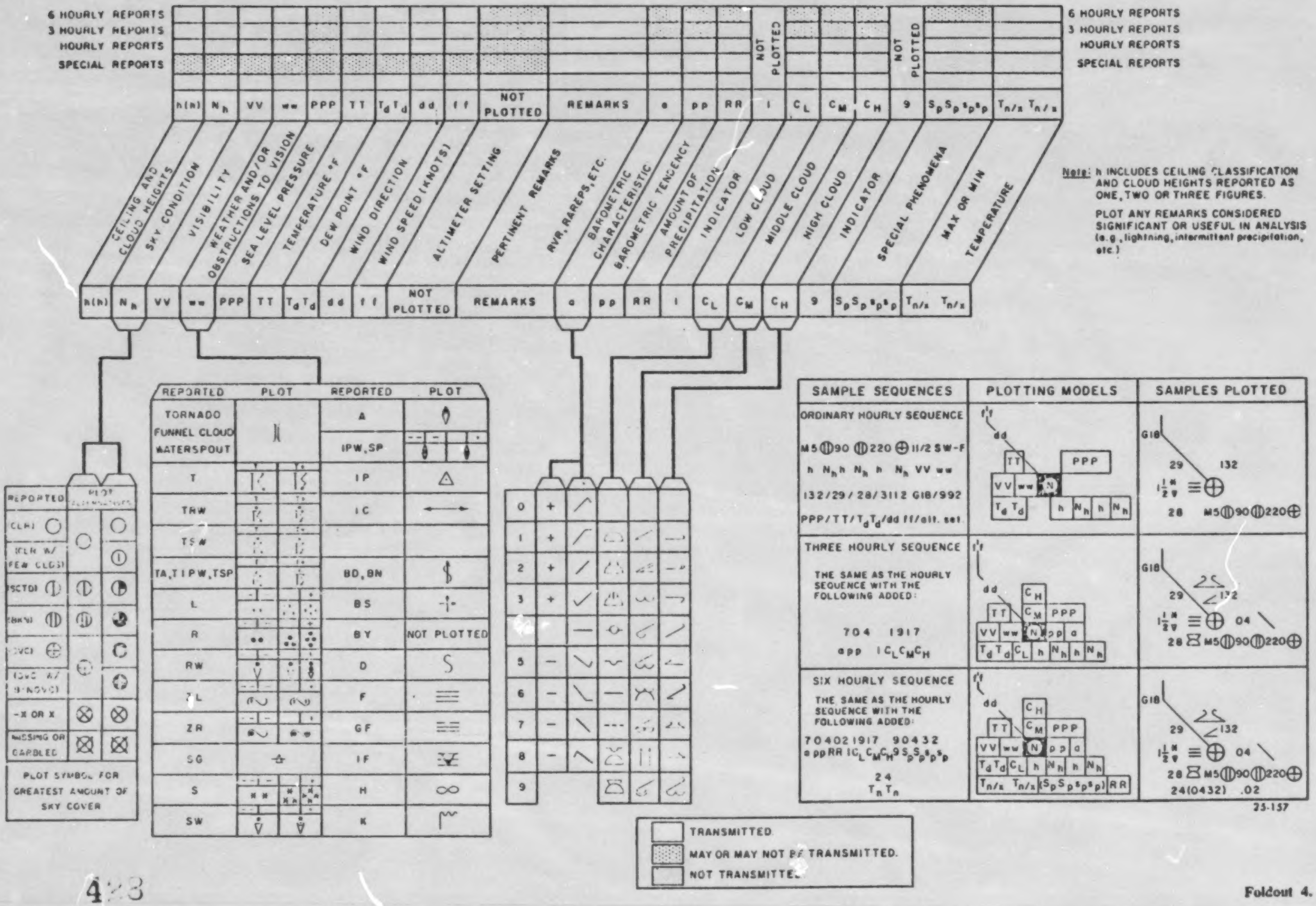
In ww code figures 00,01,02, and 03 the circle shown in the table represents the station circle. If the wind shaft interferes with plotting of the short lines, these lines are moved slightly in a clockwise direction.

Time of report (GG) will be entered when other than the synoptic time of the chart being plotted.

Symbols for ww in code figures 93, 94, 95, and 97, and for W=3, are alternates. The temperature, station location, or remarks will normally indicate which should be plotted. When in doubt, both symbols are entered.

```
FM 21 FULL SHIP:  99302  70750  12064  83030  48816
                  00017  55424  14204  85618  92135
                  0//12  11224  31304
```

PLOTTING GUIDE, AIRWAYS CODE

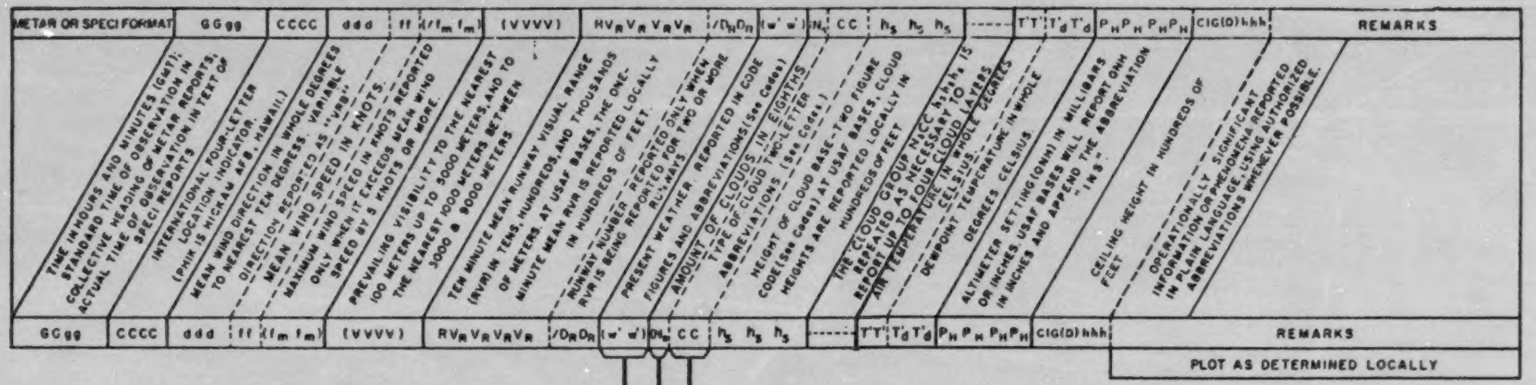
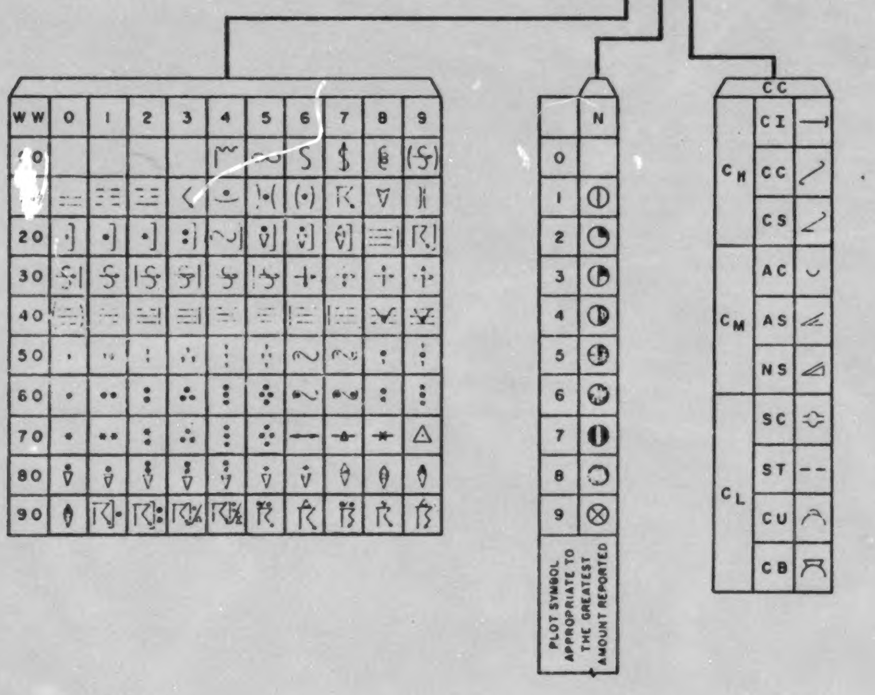

6 HOURLY REPORTS
3 HOURLY REPORTS
HOURLY REPORTS
SPECIAL REPORTS
h(h)
N_h
VV
ww
PPP
TT
T_d T_d
dd
ff
NOT PLOTTED
REMARKS
a
pp
RR
I
C_L
C_M
C_H
9
S_p S_p s_p s_p
T_n/x T_n/x
CEILING AND CLOUD HEIGHTS
SKY CONDITION
VISIBILITY
WEATHER AND/OR OBSTRUCTIONS TO VISION
SEA LEVEL PRESSURE
TEMPERATURE °F
DEW POINT °F
WIND DIRECTION
WIND SPEED (KNOTS)
ALTIMETER SETTING
PERTINENT REMARKS
RVR, RAREPS, ETC.
BAROMETRIC CHARACTERISTIC
BAROMETRIC TENDENCY
AMOUNT OF PRECIPITATION
INDICATOR
LOW CLOUD
MIDDLE CLOUD
HIGH CLOUD
INDICATOR
SPECIAL PHENOMENA
MAX OR MIN TEMPERATURE
REPORTED
PLOT ALTERNATIVES
CLR
CLR W/ FEW CLDS
SCTD
BKN
OVC
OVC W/ BINOVC
-X OR X
MISSING OR GARBLED
PLOT SYMBOL FOR GREATEST AMOUNT OF SKY COVER
REPORTED
PLOT
TORNADO
FUNNEL CLOUD
WATERSPOUT
T
TRW
TSW
TA, TIPW, TSP
L
R
RW
ZL
ZR
SG
S
SW
A
IPW, SP
IP
IC
BD, BN
BS
BY
NOT PLOTTED
D
F
GF
IF
H
K
0
1
2
3
5
6
7
8
9
SAMPLE SEQUENCES
PLOTTING MODELS
SAMPLES PLOTTED
ORDINARY HOURLY SEQUENCE
M5 ⦶90 ⦶220 ⊕ 11/2 SW-F
h N_h h N_h h N_h VV ww
132/29/28/3112 G18/992
PPP/TT/T_d T_d/dd ff/alt. set.
THREE HOURLY SEQUENCE
THE SAME AS THE HOURLY SEQUENCE WITH THE FOLLOWING ADDED:
704 1917
app IC_L C_M C_H
SIX HOURLY SEQUENCE
THE SAME AS THE HOURLY SEQUENCE WITH THE FOLLOWING ADDED:
704021917 90432
a pp RR IC_L C_M C_H 9S_p S_p s_p s_p
24
T_n T_n
PPP
TT
VV
ww
N
h
N_h
C_H
C_M
pp
a
C_L
G18
29
132
1 1/2 V
28
M5 ⦶90 ⦶220 ⊕
04
24(0432)
.02
23-157
TRANSMITTED
MAY OR MAY NOT BE TRANSMITTED.
NOT TRANSMITTED.

Note: h INCLUDES CEILING CLASSIFICATION AND CLOUD HEIGHTS REPORTED AS ONE, TWO OR THREE FIGURES.

PLOT ANY REMARKS CONSIDERED SIGNIFICANT OR USEFUL IN ANALYSIS (e.g., lightning, intermittent precipitation, etc.)

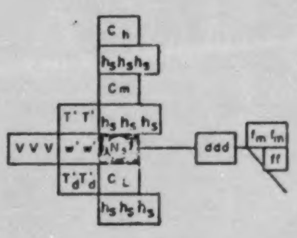
Foldout 4.

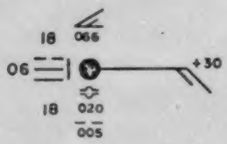
PLOTTING GUIDE METAR CODE



METAR OR SPECI FORMAT
GGgg
CCCC
ddd
ff
(/fm fm)
(VVVV)
RVR VR VR VR
/DR DR
(w' w')
Ns
CC
hs hs hs
T'T'
T'd T'd
PH PH PH PH
CIG(D)hhh
REMARKS
PLOT AS DETERMINED LOCALLY
WW
0 1 2 3 4 5 6 7 8 9
00 10 20 30 40 50 60 70 80 90
N
0 1 2 3 4 5 6 7 8 9
PLOT SYMBOL APPROPRIATE TO THE GREATEST AMOUNT REPORTED
CC
CH
CI
CC
CS
CM
AC
AS
NS
CL
SC
ST
CU
CB

GGgg	TIME IN HOURS AND MINUTES (GMT); STANDARD TIME OF OBSERVATION IN COLLECTIVE HEADING OF METAR REPORTS; ACTUAL TIME OF OBSERVATION IN TEXT OF SPECI REPORTS
CCCC	INTERNATIONAL FOUR-LETTER LOCATION INDICATOR. (PHIK IS HICKAM AFB, HAWAII.)
ddd	MEAN WIND DIRECTION IN WHOLE DEGREES TO NEAREST TEN DEGREES. VARIABLE DIRECTION REPORTED AS "VRB".
ff	MEAN WIND SPEED IN KNOTS.
(/$f_m f_m$)	MAXIMUM WIND SPEED IN KNOTS REPORTED ONLY WHEN IT EXCEEDS MEAN WIND SPEED BY 5 KNOTS OR MORE.
(VVVV)	PREVAILING VISIBILITY TO THE NEAREST 100 METERS UP TO 5000 METERS, AND TO THE NEAREST 1000 METERS BETWEEN 5000 & 9000 METERS
$RV_RV_RV_RV_R$	TEN MINUTE MEAN RUNWAY VISUAL RANGE (RVR) IN TENS, HUNDREDS, AND THOUSANDS OF METERS. AT USAF BASES, THE ONE-MINUTE MEAN RVR IS REPORTED LOCALLY IN HUNDREDS OF FEET.
/D_RD_R	RUNWAY NUMBER REPORTED ONLY WHEN RVR IS BEING REPORTED FOR TWO OR MORE RUNWAYS
(w' w')	PRESENT WEATHER. REPORTED IN CODE FIGURES AND ABBREVIATIONS (See Codes)
N_s	AMOUNT OF CLOUDS IN EIGHTHS
CC	TYPE OF CLOUD TWO-LETTER ABBREVIATIONS (See Codes.)
$h_s h_s h_s$	HEIGHT OF CLOUD BASE-TWO FIGURE CODE (See Codes) AT USAF BASES, CLOUD HEIGHTS ARE REPORTED LOCALLY IN HUNDREDS OF FEET
-----	THE CLOUD GROUP $N_sCC\ h_sh_sh_s$ IS REPEATED AS NECESSARY TO REPORT UP TO FOUR CLOUD LAYERS
T'T'	AIR TEMPERATURE IN WHOLE DEGREES CELSIUS.
$T'_dT'_d$	DEWPOINT TEMPERATURE IN WHOLE DEGREES CELSIUS
$P_HP_HP_HP_H$	ALTIMETER SETTING (QNH) IN MILLIBARS OR INCHES. USAF BASES WILL REPORT QNH IN INCHES AND APPEND THE ABBREVIATION "INS".
CIG(D)hhh	CEILING HEIGHT IN HUNDREDS OF FEET
REMARKS	OPERATIONALLY SIGNIFICANT INFORMATION OR PHENOMENA REPORTED IN PLAIN LANGUAGE, USING AUTHORIZED ABBREVIATIONS WHENEVER POSSIBLE.

PHIK 09015/30 0600 R0850 42FG 3ST005 5SC 020 8AS 066
18/18 2984 INS/CIGM020 IFG//


Ch
hshshs
Cm
T'T'
hs hs hs
VVV
w' w'
Ns
ddd
fm fm
ff
T'dT'd
CL
hs hs hs


18
066
06
+30
18
020
005

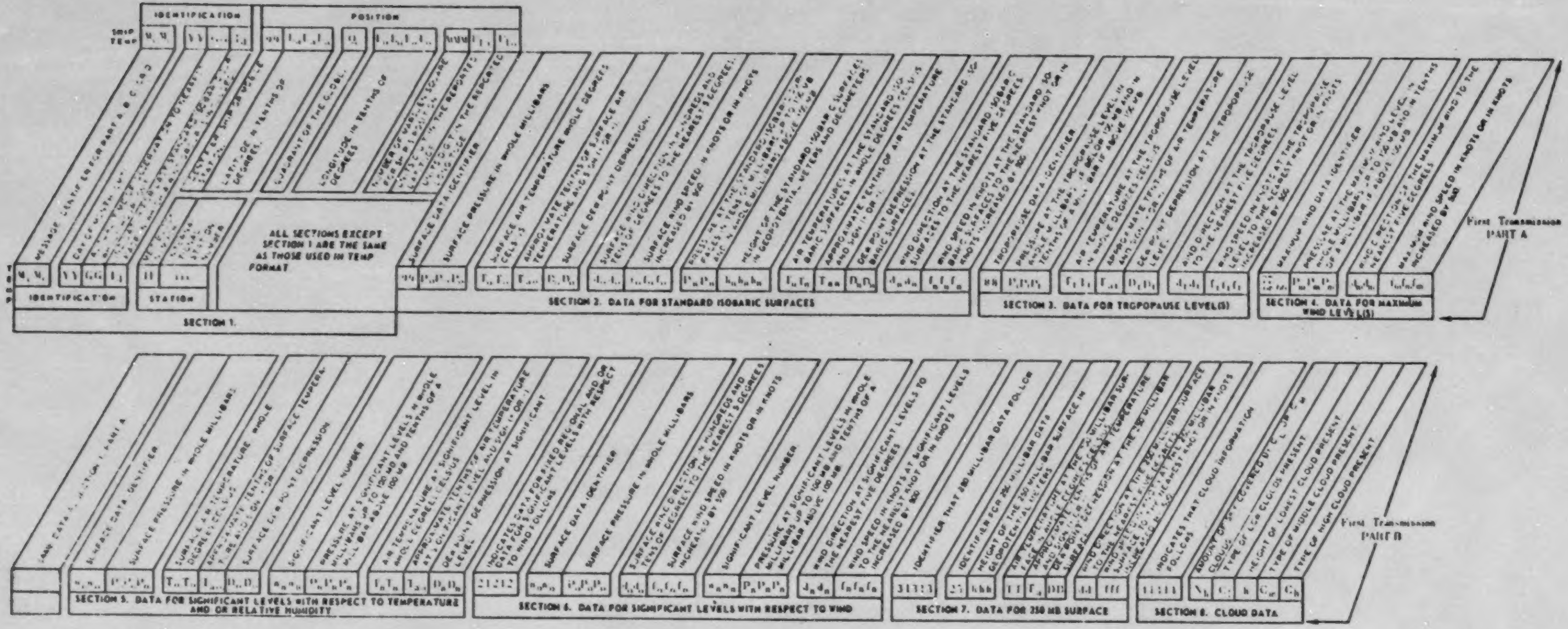
Notes:

Symbols for ww in code figures 93, 94, 95 and 97 are alternates. The temperature, station location, or remarks will normally indicate which should be plotted. When in doubt, both symbols are entered.

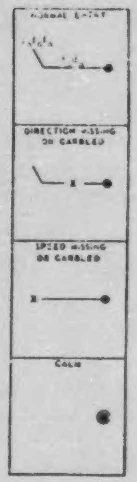
23-158

Foldout 5.

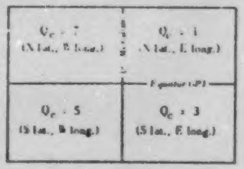
PLOTTING GUIDE, CONSTANT PRESSURE CHART

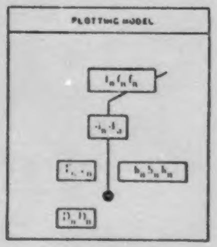

IDENTIFICATION
POSITION
SHIP TEMP
TEMP
MESSAGE IDENTIFIER FOR PART A, B, C, D
IDENTIFICATION
STATION
SECTION 1.
ALL SECTIONS EXCEPT SECTION 1 ARE THE SAME AS THOSE USED IN TEMP FORMAT
SURFACE DATA IDENTIFIER
SURFACE PRESSURE IN WHOLE MILLIBARS
SURFACE AIR TEMPERATURE WHOLE DEGREES CELSIUS
SURFACE DEW POINT DEPRESSION
SURFACE WIND DIRECTION
SURFACE WIND SPEED IN KNOTS OR IN KNOTS INCREASED BY 500
HEIGHT OF THE STANDARD ISOBARIC SURFACES IN GEOPOTENTIAL METERS AND DECAMETERS
AIR TEMPERATURE AT THE STANDARD ISOBARIC SURFACES
DEW POINT DEPRESSION AT THE STANDARD ISOBARIC SURFACES
WIND DIRECTION AT THE STANDARD ISOBARIC SURFACES TO THE NEAREST FIVE DEGREES
WIND SPEED IN KNOTS AT THE STANDARD ISOBARIC SURFACES
SECTION 2. DATA FOR STANDARD ISOBARIC SURFACES
TROPOPAUSE DATA IDENTIFIER
PRESSURE AT THE TROPOPAUSE LEVEL
AIR TEMPERATURE AT THE TROPOPAUSE LEVEL
DEW POINT DEPRESSION AT THE TROPOPAUSE LEVEL
WIND DIRECTION AT THE TROPOPAUSE LEVEL TO THE NEAREST FIVE DEGREES
WIND SPEED IN KNOTS AT THE TROPOPAUSE LEVEL
SECTION 3. DATA FOR TROPOPAUSE LEVEL(S)
MAXIMUM WIND DATA IDENTIFIER
PRESSURE AT THE MAXIMUM WIND LEVEL
WIND DIRECTION TO THE NEAREST FIVE DEGREES
MAXIMUM WIND SPEED IN KNOTS OR IN KNOTS INCREASED BY 500
SECTION 4. DATA FOR MAXIMUM WIND LEVEL(S)
First Transmission PART A
SURFACE DATA IDENTIFIER
SURFACE PRESSURE IN WHOLE MILLIBARS
SURFACE DEW POINT DEPRESSION
SIGNIFICANT LEVEL NUMBER
PRESSURE AT SIGNIFICANT LEVELS
AIR TEMPERATURE AT SIGNIFICANT LEVEL
DEW POINT DEPRESSION AT SIGNIFICANT LEVEL
SECTION 5. DATA FOR SIGNIFICANT LEVELS WITH RESPECT TO TEMPERATURE AND OR RELATIVE HUMIDITY
21212
INDICATES DATA FOR SIGNIFICANT LEVELS WITH RESPECT TO WIND FOLLOWS
SURFACE DATA IDENTIFIER
SURFACE PRESSURE IN WHOLE MILLIBARS
SURFACE WIND DIRECTION
SURFACE WIND SPEED IN KNOTS OR IN KNOTS INCREASED BY 500
SIGNIFICANT LEVEL NUMBER
PRESSURE AT SIGNIFICANT LEVELS
WIND DIRECTION AT SIGNIFICANT LEVELS TO THE NEAREST FIVE DEGREES
WIND SPEED IN KNOTS AT SIGNIFICANT LEVELS
SECTION 6. DATA FOR SIGNIFICANT LEVELS WITH RESPECT TO WIND
31313
IDENTIFIER THAT 250 MILLIBAR DATA FOLLOW
IDENTIFIER FOR 250 MILLIBAR DATA
HEIGHT OF THE 250 MILLIBAR SURFACE IN GEOPOTENTIAL METERS
SECTION 7. DATA FOR 250 MB SURFACE
41414
INDICATES THAT CLOUD INFORMATION FOLLOWS
AMOUNT OF SKY COVERED BY CLOUDS
TYPE OF LOW CLOUDS PRESENT
HEIGHT OF LOWEST CLOUD PRESENT
TYPE OF MIDDLE CLOUD PRESENT
TYPE OF HIGH CLOUD PRESENT
SECTION 8. CLOUD DATA
First Transmission PART B

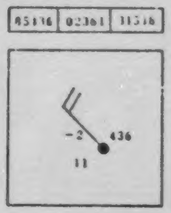
SCHEMATIC ENTRIES

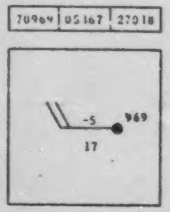

NORMAL ENTRY
DIRECTION MISSING OR GARBLED
SPEED MISSING OR GARBLED
CALM

CODE FIGURE	SIGN	TENTHS OF AIR TEMPERATURE
0	+	0.0 AND 0.1°
1	−	0.0 AND 0.1°
2	+	0.2 AND 0.3°
3	−	0.2 AND 0.3°
4	+	0.4 AND 0.5°
5	−	0.4 AND 0.5
6	+	0.6 AND 0.7°
7	−	0.6° AND 0.7
8	+	0.8° AND 0.9°
9	−	0.8 AND 0.9°


$Q_c = 7$ (N lat., W long.)
$Q_c = 1$ (N lat., E long.)
$Q_c = 5$ (S lat., W long.)
$Q_c = 3$ (S lat., E long.)
Equator


PLOTTING MODEL


85136
02361
31516
-2
436
11


70969
05367
27018
-5
969
17

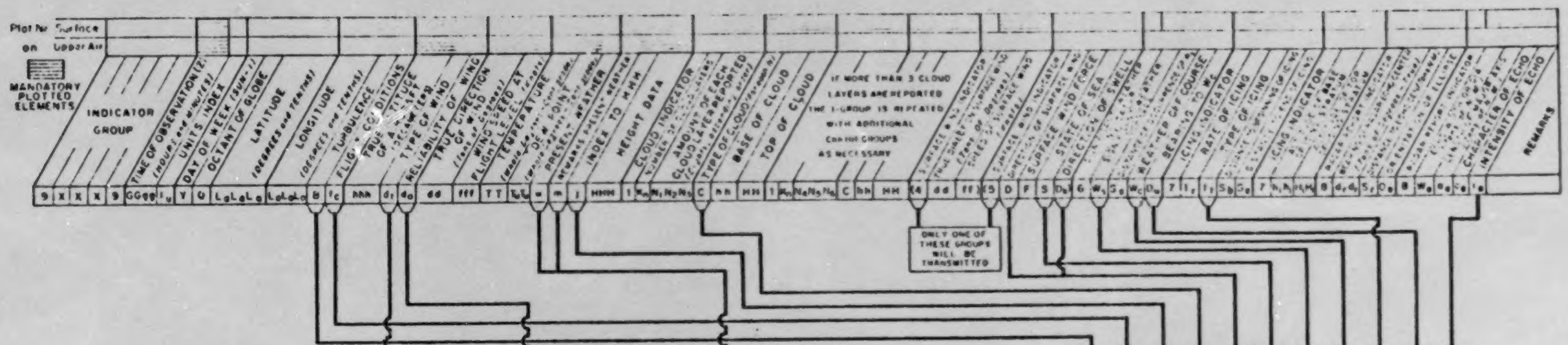
NOTES.

1. THE SECOND TRANSMISSION WILL INCLUDE THE FOLLOWING
   - A. PART C (SECTIONS 1, 2, 3, AND 4)
   - B. PART D (SECTIONS 1, 5, AND 6)
2. INDICATOR GROUP 51515 IS FOLLOWED BY REGIONALLY DEVELOPED CODE GROUPS.
3. CONSTANT PRESSURE DATA MAY BE ABSTRACTED ALSO FROM RECCO AND AIREP CODE REPORTS. INDICATOR 17171 WILL PREFACE RECCO ASCENT DATA AND 71717 WILL PREFACE RECCO DROPSONDE DATA.
4. DOUBTFUL DATA WILL BE ENCLOSED IN PARENTHESES.
5. EXTRAPOLATED HEIGHT DATA WILL BE UNDERLINED.

25-159

Foldout 6.

PLOTTING GUIDE, RECCO CODE

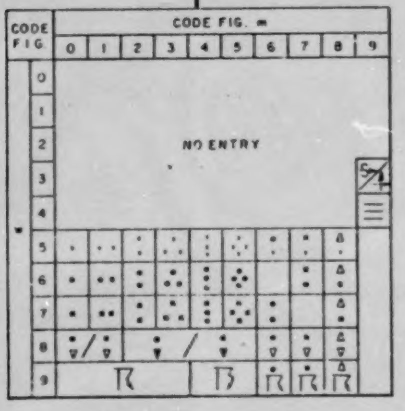

Plot No. Surface
on Upper Air
MANDATORY PLOTTED ELEMENTS
INDICATOR GROUP
TIME OF OBSERVATION (Z) (HOURS and MINUTES)
UNITS INDEX
DAY OF WEEK (SUN-1)
OCTANT OF GLOBE
LATITUDE (DEGREES and TENTHS)
LONGITUDE (DEGREES and TENTHS)
TURBULENCE
FLIGHT CONDITIONS
TRUE ALTITUDE OF AIRCRAFT
TYPE OF WIND
RELIABILITY OF WIND
TRUE DIRECTION OF WIND
WIND SPEED
FLIGHT LEVEL TEMPERATURE
DEW POINT
PRESENT WEATHER
INDEX TO HHH
HEIGHT DATA
CLOUD INDICATOR
AMOUNT OF EACH CLOUD LAYER REPORTED
TYPE OF CLOUD
BASE OF CLOUD
TOP OF CLOUD
IF MORE THAN 3 CLOUD LAYERS ARE REPORTED THE 1-GROUP IS REPEATED WITH ADDITIONAL ChhHH GROUPS AS NECESSARY
SURFACE WIND INDICATOR
SURFACE WIND FORCE
STATE OF SEA
DIRECTION OF SWELL
BEARING TO Wc
ICING INDICATOR
RATE OF ICING
TYPE OF ICING
ICING INDICATOR
CHARACTER OF ECHO
INTENSITY OF ECHO
REMARKS
9 X X X 9 GGgg iu Y Q LaLaLa LoLoLo B fc hhh di da dd fff TT TdTd w m j HHH 1 Nh N1N2N3 C hh HH 1 Nh N4N5N6 C hh HH 4 dd ff 5 D F S Dk 6 Ws Sa Wc Dw 7 It Ic SbSe 7 hihiHiHi 8 drdr Sr Oe 8 We ee ce ie
ONLY ONE OF THESE GROUPS WILL BE TRANSMITTED

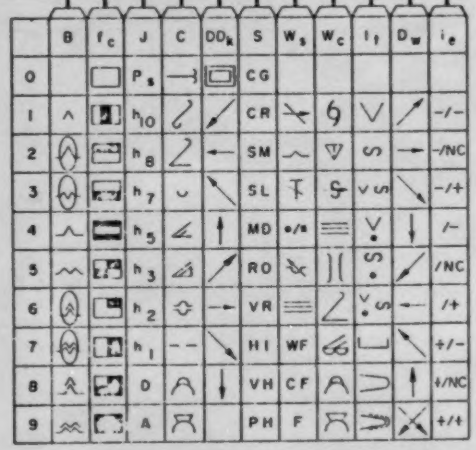
Note
ddfff group is omitted from report when $d_t d_a$ is /8

CODE FIG. d_a
(To be entered at base of plotted wind for all values of d_t except zero)

CODE FIG. d_t

CODE FIG	PLOTTED POSITION NAUT MILES BACK ALONG FLT TRACK
0	PLOT ON REPORT EXACT POSITION
1	75 N MI
2	125
3	175
4	225
5	125
6	175
7	225
8	275
9	300


CODE FIG. m
CODE FIG.
0 1 2 3 4 5 6 7 8 9
w
NO ENTRY


B
fc
J
C
DDk
S
Ws
Wc
It
Dw
ie
Ps
h10
h8
h7
h5
h3
h2
h1
D
A
CG
CR
SM
SL
MD
RO
VR
HI
VH
PH
WF
CF
F
-/-
-/NC
-/+
/-
/NC
/+
+/-
+/NC
+/+

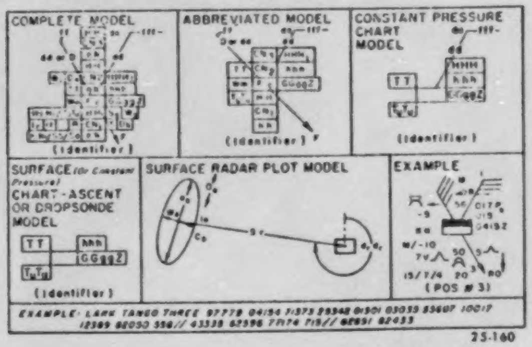

COMPLETE MODEL
ABBREVIATED MODEL
CONSTANT PRESSURE CHART MODEL
(identifier)
SURFACE (Or Constant Pressure) CHART - ASCENT OR DROPSONDE MODEL
TT
hhh
GGggZ
SURFACE RADAR PLOT MODEL
EXAMPLE
(POS # 3)
EXAMPLE: LARK TANGO THREE 97779 04194 71373 29348 01301 03033 55607 10017 12389 82050 356// 43339 67596 7H74 715// 82891 82433

TABLE 1 9XXX9

000	NOT USED	
111	English Units - Heights in feet	RECCO REPORTS WITHOUT RADAR DATA
222	Metric Units - Heights in meters	
333	Pressure (Millibars)	
444	NOT USED	
555	NOT USED	
666	English Units - Heights in feet	RECCO REPORTS WITH RADAR
777	Metric Units - Heights in meters	
888	Pressure (Millibars)	
999	NOT USED	

TABLE 2 i_u

0	%	No Humidity Reported
1	%	Relative Humidity Reported
2	°C	Wet Bulb Depression Reported
3	°C	Dew Point Depression Reported
4	°C	Dew Point Reported

TABLE 3 Q

0	0° - 90°W	North Latitude
1	90°W - 180°	
2	180° - 90°E	
3	90° - 0°E	
4	NOT USED	
5	0° - 90°W	South Latitude
6	90°W - 180°	
7	180° - 90°E	
8	90° - 0°E	
9	NOT USED	

TABLE 4 O_e

0	CIRCULAR	5	ESE - WNW
1	NNE - SSW	6	SE - NW
2	NE - SW	7	SSE - NNW
3	ENE - WSW	8	S - N
4	E - W	9	Uncertain

TABLE 5 c_e

1	SCT
2	SLD
3	SCT LN
4	SLD LN
5	SCT ALQDS
6	SLD ALQDS

TABLE 6 S_bS_e and S_r

0	No Report
1	Previous Position
2	Present Position
3	20 n m
4	40 n m
5	60 n m
6	80 n m
7	100 n m
8	150 n m
9	More Than 150 n m

25-160

Foldout 7.

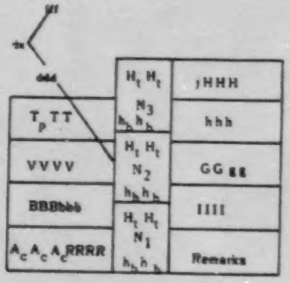
PLOTTING GUIDE, COMBAR CODE

A	B	C	D	E	F	G	H	I	JKL	M	N	O	P	
LATITUDE IN DEGREES (FIRST TWO DIGITS) MINUTES (THIRD AND FOURTH DIGITS), AND DIRECTION (NORTH OR SOUTH).	LONGITUDE IN DEGREES (FIRST THREE DIGITS), MINUTES (FOURTH AND FIFTH DIGITS), AND DIRECTION (EAST OR WEST).	TIME (GMT).	FLIGHT LEVEL	TEMPERATURE	WIND DIRECTION AND SPEED	D-VALUE	TURBULENCE	VISIBILITY	SKY COVERAGE (BELOW, AT, ABOVE FLIGHT LEVEL).	VISIBILITY OF REFUELING	CONTRAILS	AIRCRAFT HEADING (CODED ONLY WHEN CAT IS REPORTED).	BASE OF CLOUD, SKY COVERAGE, TOP OF CLOUD; BELOW, AT, AND ABOVE FLIGHT LEVEL.	PLAIN LANGUAGE REMARKS.
$L_aL_aL_aL_aL_d$	$L_oL_oL_oL_oL_oL_d$	GGgg	hhh	T_pTT	$d_x$ddd fff	jHHHH	BBBbbb	VVVV	$N_1N_2N_3$	RRRR	IIII	$A_cA_cA_c$	$h_bh_bN_nH_tH_t$	Remarks

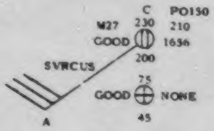
CODED REPORT:

3431N 11946W 1656 210 M27 A230/030 PO150 SVRCUS GOOD VBC GOOD NONE /// 45V75 200B230

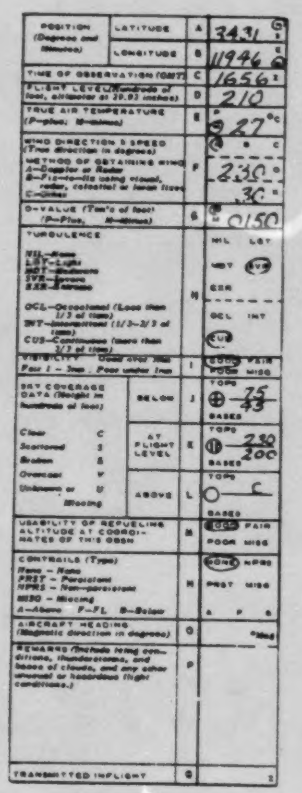
PLOTTING MODEL



EXAMPLE



25-161



POSITION (Degrees and Minutes)	LATITUDE	A	3431 [✓ N] S
	LONGITUDE	B	11946 E [✓ W]
TIME OF OBSERVATION (GMT)		C	1656 Z
FLIGHT LEVEL (Hundreds of feet, altimeter at 29.92 inches)		D	210
TRUE AIR TEMPERATURE (P—plus; M—minus)		E	P [✓ M] 27 °C
WIND DIRECTION & SPEED (True direction in degrees) METHOD OF OBTAINING WIND A—Doppler or Radar B—Fix-to-fix using visual, radar, celestial or loran fixes C—Other		F	[✓ A] B C 230 ° 30 K
D-VALUE (Ten's of feet) (P—Plus, M—Minus)		G	[✓ P] M 0150
TURBULENCE NIL—None LGT—Light MDT—Moderate SVR—Severe EXR—Extreme OCL—Occasional (Less than 1/3 of time) INT—Intermittent (1/3–2/3 of time) CUS—Continuous (more than 2/3 of time)		H	NIL LGT MDT [✓ SVR] EXR OCL INT [✓ CUS]
VISIBILITY Good over 3mi Fair 1 - 3mi, Poor under 1mi		I	[✓ GOOD] FAIR POOR MISG
SKY COVERAGE DATA (Height in hundreds of feet) Clear C Scattered S Broken B Overcast V Unknown or Missing U	BELOW	J	TOPS ⊕ 75/45 BASES
	AT FLIGHT LEVEL	K	TOPS ◍ 230/200 BASES
	ABOVE	L	TOPS ○ C BASES
USABILITY OF REFUELING ALTITUDE AT COORDINATES OF THIS OBSN		M	[✓ GOOD] FAIR POOR MISG
CONTRAILS (Type) None – None PRST – Persistent NPRS – Non-persistent MISG – Missing A—Above F—FL B—Below		N	[✓ NONE] NPRS PRST MISG A F B
AIRCRAFT HEADING (Magnetic direction in degrees)		O	°Mag
REMARKS (Include icing conditions, thunderstorms, and bases of clouds, and any other unusual or hazardous flight conditions.)		P	
TRANSMITTED INFLIGHT		Q	Z

Foldout 8.

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PLOTTING GUIDE, AIREP CODE (ICAO CODE FORM)

ITEM NUMBER	1	2		3	4	8	9			10	11	12
	IDENTIFICATION	LATITUDE (Degrees and Minutes)	LONGITUDE (Degrees and Minutes)	TIME (GMT)	FLIGHT LEVEL (FL) OR ALTITUDE (ALT)	TEMPERATURE (°C)	WIND DIRECTION & SPEED (Spot wind/mean thereof)	LATITUDE OF MEAN WIND	LONGITUDE OF MEAN WIND	TURBULENCE	ICING	REMARKS (Height of cloud bases/tops, hh and/or HH; sky cover, Nh; weather, ww; D-value, HHHH PS/MS; other supplementary information)
								"SPOT" OR				
	iiiii	LaLaLaLaLd	LoLoLoLoLoLd	GGgg	hhh	TpTT	ddfff	LaLaLd	LoLoLoLoLd	BBB bbb	IcIcIc IcIcIc	(REMARKS)
	C0322	2000N	17000E	1959	FL 310	MS 40	10020	20N	170 E			

ww	PLOT
RAIN (RA)	●
SNOW (SN)	✱
RAIN AND SNOW	● ✱
FREEZING RAIN (FZR)	●∼
HAIL	▲
ICE PELLETS	◬
THUNDERSTORMS (TS)	Ʀ
LIGHTNING	ϟ
WTSPT or TDO	)(

PLOT PHENOMENA FOR A POSITION OTHER THAN THAT IN ITEM 2 AS RECEIVED AND AS A REMARK.

Nh	PLOT
SCT	⦶
BKN	⦷
CNS	⊕

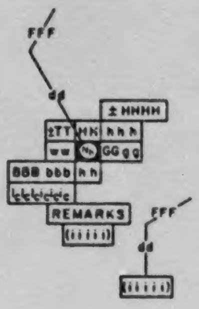
BBB bbb	PLOT
TURB MOD	⋀
TURB SEV	⩕

IcIcIc IcIcIc	PLOT
ICE MOD	Ψ
ICE SEV	ΨΨ

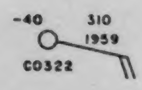
Note:

Plot any deviations in the code form using standard procedures whenever possible

PLOTTING MODEL



EXAMPLE



Foldout 9

PLOTTING GUIDE, AIREP CODE (MAC CODE FORM)

AIRCRAFT NUMBER *(MAC-MPJ)*					CURRENT POSITION DATA																					FLIGHT LEVEL *(Hundred of feet)*		
					DEGREES AND MINUTES											GMT TIME							
					LATITUDE					LONGITUDE													
i	i	i	i	i	L_a	L_a	L_a	L_a	N/S	L_o	L_o	L_o	L_o	L_o	E/W	G	G	g	g	Z	h	h	h
7	6	2	2	0	4	9	4	9	[✓ N]/S	0	3	0	0	0	E/[✓ W]	0	2	0	4	Z	3	7	0

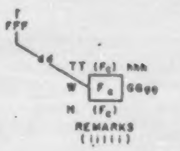
WIND AT MID POINT OR AVERAGE WIND *(In tens of true degrees)*					MID POINT							TEMP P/MTT(°C) P-PLUS M-MINUS			WEATHER HWFC *(See Tables Below)*			WIND AT CURRENT POSITION *(In Tens Of True Degrees Spot Winds Only, If None Available Leave Blank)*					PLAIN LANGUAGE REMARKS
					(Degrees Only)																		
					LAT			LONGITUDE															
d	d	F	F	F	L_a	L_a	N/S	L_o	L_o	L_o	E/W	P/M	T	T	H	W	F_c	d	d	F	F	F	
3	1	0	6	5	5	0	[✓ N]/S	0	3	5	E/[✓ W]	P/[✓ M]	5	-5	2	2	1	3	0	0	6	9	

H	PLOT
0	
1	∧
2	⋀
3	⩚
4	EXTREME TURB
5	TRACE ICE
6	Ψ
7	Ψ
8	Ψ
9	△
/	m

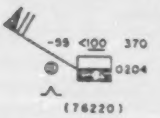
W	PLOT
0	
1	⦶
2	⦷
3	⊕
4	<
5	,
6	●
7	✱
8	▽
9	R
/	m

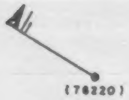
F_c	PLOT	
0		
1	▨	$<\underline{100}$
2	▨	$\underline{100-180}$
3	▨	$>\underline{180}$
4	▨	$<\overline{100}$
5	▨	$\overline{100-180}$
6	▨	$>\overline{180}$
7	▨	
8	▨	
9	▨	
/	m	

PLOTTING MODEL



EXAMPLE





Notes:-

Plot mid point or average wind at reported position, with base (point) of the wind shaft terminating at that position.

Plot (F_c) height data for cloud bases below the position square and for cloud tops above the position square.

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Foldout 9. Plotting guide AIREP code

25251 04 7204

CDC 25251

WEATHER OBSERVER

(AFSC 25251)

Volume 4

Upper Air Observations and Tactical Stations

15-1

Extension Course Institute

Air University

CHANGES FOR THE TEXT: VOLUME 4

iii	Last line		Change currency date to "April 1974."
16	2-25	3	Insert "the" after "and."
31	8-4(b)	6	Change "140,0000" to "140,000."
32	9-1	1	Change "Robet" to "Robert."
41	9-23	2	Insert "to" between "forwarded" and "the."
41	10-1, Col 2	7	Change "WE-135B" to "WC-135B."
41	10-2,*d*		Change "402.5" to "403.0."
48	10-5	4	Change the word "mechanic" to "engineer."
49	10-10	8	Change "dispenser" to "computer."
49	10-11	11	Change "sensor end down" to "sensor end up."
50	10-13	7	Change "CD-821" to "CP-821."
57	10-18	1	Change "TT" to "UUAA."
57	10-18	9 thru 19	Delete and replace with:

URPA RJTZ 020205
AIR FORCE ROBIN SERRIA OBS 3 DROP
97779 71717
UUAA 0276/ 99429 11550 16525 99024 12000 00202
18800 85541 06666 70121 00261 50573 151// 88999
77999

UUBB 0276/ 99429 11550 16525 00024 12000 11882
03600 22850 06666 33800 06065 44616 07162 55592
08758 66500 151// 51515 10168 05950

DEPARTMENT OF THE AIR FORCE
UNITED STATES OF AMERICA

PREPARED BY
DEPARTMENT OF WEATHER TRAINING
3345TH TECHNICAL SCHOOL (ATC)
CHANUTE AFB, ILLINOIS

EXTENSION COURSE INSTITUTE, GUNTER AIR FORCE BASE, ALABAMA

THIS PUBLICATION HAS BEEN REVIEWED AND APPROVED BY COMPETENT PERSONNEL OF THE PREPARING COMMAND IN ACCORDANCE WITH CURRENT DIRECTIVES ON DOCTRINE, POLICY, ESSENTIALITY, PROPRIETY, AND QUALITY.

Preface

IN ORDER to gather data within the region of what we call outer space, but still relatively close to the earth's surface, it is necessary that we get measuring devices into these regions. With the refinement of the upper air balloon and the instruments that it carries aloft, frequent soundings up to 100,000 feet have been obtained. By using rocketsondes, this height has been raised to over 200,000 feet.

Your assignment may take you to a location where you must be completely familiar with the methods and procedures of taking upper air observations. Also, your assignment may require you to be proficient in the use of Tactical Weather Sets. These two subjects, essential in the performance of your duties, are discussed in this final volume of CDC 25251.

The discussion of upper air observations includes the methods and procedures of preflight and tracking of upper air instruments, and the plotting and measurement of upper aid data. The discussion of Tactical Weather Sets familiarizes you with the types of sets and with the unpacking, installation, operation, maintenance, and safety precautions to observe when using the sets.

Printed and bound in the back of this volume is one foldout numbered FO 1. This foldout contains a breakdown of the Rocketsonde Code.

Code numbers appearing on figures do not concern you. They serve merely to identify the figure for the preparing agency.

If you have questions on the accuracy or currency of the subject matter of this text, or recommendations for its improvement, send them to Tech Tng Cen (TTOC), Chanute AFB, IL 61868

If you have questions on course enrollment or administration, or on any of ECI's instructional aids (Your Key to Career Development, Study Reference Guides, Chapter Review Exercises, Volume Review Exercise, and Course Examination), consult your education officer, training officer, or NCO, as appropriate. If he can't answer your questions, send them to ECI, Gunter AFB, AL 36118, preferably on ECI Form 17, Student Request for Assistance.

This volume is valued at 21 hours (7 points).

Material in this volume is technically accurate, adequate, and current as of December 1971.

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Chapter

1 Pilot Balloon Observations 1

2 Rawinsonde Observations 17

3 Rocketsonde and Dropsonde Observations 32

4 Tactical Weather Sets and Safety Precautions 60

Bibliography 75

Appendixes 77

Pilot Balloon Observations

WEATHER IS unalterable in at least one respect—it never stops changing. This fact and the resulting effects weather has on military operations are among the major reasons for taking upper air observations. Today man is seldom held earthbound by weather, because aircraft systems are better equipped to cope with weather. However, the cost of modern aircraft and the many lives involved make the problem of weather just as important today as in the early days of aviation.

2. Four major systems are used to obtain upper air data. Gathering upper air temperature, humidity, and winds requires elaborate electronic systems. These data, especially temperature and humidity, can be observed from a rawinsonde, dropsonde, or rocketsonde system using electronic gear. If there is a need for information on winds alone, a pibal observation satisfies that need. Pibal observations can be made without the aid of an electronic system. This chapter covers the procedures for making pibal observations and plotting the acquired data.

3. Each method of upper air observation—rawinsonde, dropsonde, or rocketsonde—offers a specific advantage. These methods also pay tribute to the ingenuity of man to obtain data by remote means. However, as the system becomes more elaborate, the cost of observation rises. Upper data, when needed without temperatures or other elements, may be observed by releasing and tracking a pilot balloon. The equipment used is not as expensive, and can be transported by an observer. The balloon is tracked visually rather than electronically.

1. Preflight and Tracking

1-1. This section discusses the theodolite, balloon preparation, and pibal release and tracking. In the following section, we look at pibal plotting, measuring speed and direction, graphing wind data, and encoding the message. Your objective in this section is to be able to understand the basic procedures in taking pibal observations. The need may not exist at your present assignment to actually take these observations. However, the knowledge from this section, along with a short period of OJT, should enable you to take a pibal observation if the need should develop at a later time.

1-2. **Theodolite.** Identifying the parts of a theodolite can best be done by an illustration. Figure 1 points out the major parts. The theodolite mount provides for easy rotation through 360° of azimuth and a 180° elevation arc. A prism arrangement transfers the image from the lens to the eyepiece, but the image is shown upside down. To make an erect image would take additional lenses and a consequent reduction of light to the eyepiece. Rotation of the eyepiece *focuses the crosshairs* that help center the balloon in the field of view. Focusing of the lens may either be fixed (factory-adjusted to focus on distant objects) or adjustable. If you have an adjustable focus theodolite, there is a small adjustment knob on the side of the eyepiece. Of course, the knob is absent on fixed-focus theodolites.

1-3. Some theodolites have an auxiliary scope to permit a wider field of view. A wider field of view means greater ability to follow the balloon near the surface where low-level turbulence swings the balloon in unpredictable directions. The wider view sacrifices magnification, but there is no risk in losing sight of the balloon because of the lower power. A few minutes after release, the balloon's movement settles down, and you can switch to the higher power, narrower field, main scope. This scope provides a field of 2° (views an area whose diameter is bounded by a 2° angle) and magnifies objects about 20 times. The auxiliary scope permits a 10° field of view with its 4-power magnification. A small lever atop the eyepiece controls the shift from one scope to another. Other features include a battery-powered illuminating circuit to light the

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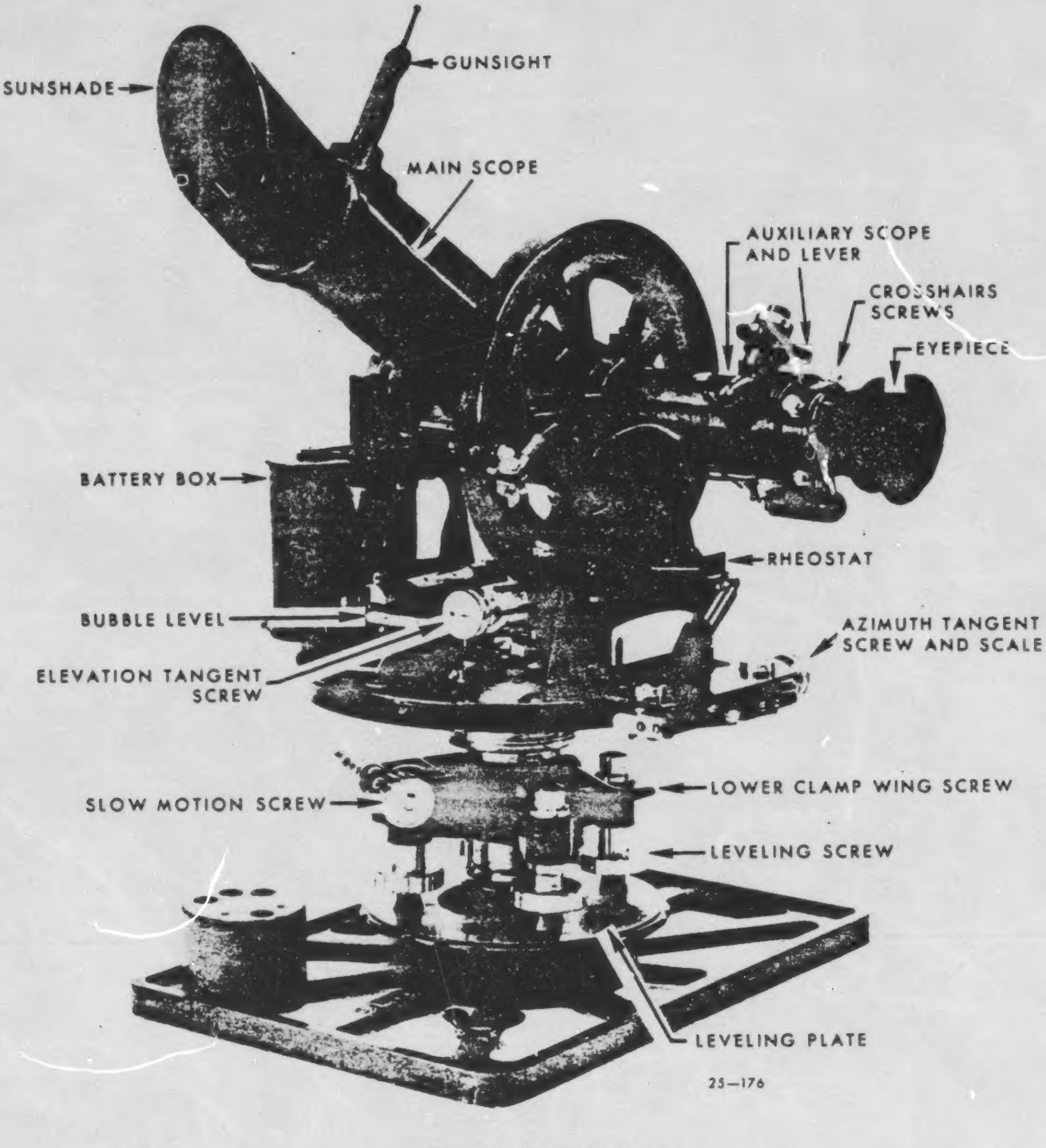
SUNSHADE
GUNSIGHT
MAIN SCOPE
AUXILIARY SCOPE AND LEVER
CROSSHAIRS SCREWS
EYEPIECE
BATTERY BOX
RHEOSTAT
BUBBLE LEVEL
ELEVATION TANGENT SCREW
AZIMUTH TANGENT SCREW AND SCALE
SLOW MOTION SCREW
LOWER CLAMP WING SCREW
LEVELING SCREW
LEVELING PLATE
25—176

Figure 1. Theodolite.

scale markings and crosshairs, and a set of gunsights along the telescope barrel to aim the telescope quickly without looking through the eyepiece. You can control the telescope's small movements by tangent screws, or you can disengage the screws and move the telescope about freely.

1-4. Tangent screws mesh with the gear-cut rims of both the azimuth and elevation circular scales. These screws permit controllable, slow-motion rotation through the range of azimuth and elevation. One complete turn of the tangent screw causes a 1° movement of the telescope. Each scale has 1° graduations. A micrometer drum built into each tangent screw divides the 1° scale into tenths. The drum is numbered from 0 to 9. When you turn the tangent screw, the micrometer drum simply divides one rotation of the screw (1°) into 10 parts. With this arrangement, you can obtain whole degrees of angle from the circular scales and tenths of a degree from the micrometer drum. Estimations between micrometer markings, for reading to .05°, can easily be made.

1-5. Before taking your pibal observation there are two important preflight operations

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you must make. They are important because they affect the accuracy of the elevation and azimuth readings. These items are leveling and orienting. A *level* theodolite is necessary for accurate *elevation*. Of these two tasks, leveling should be done first.

1-6. *Leveling*. The leveling assembly consists of two bubble levels, a leveling plate, a set of four leveling thumbscrews, and a plumb bob. Figure 1 shows this assembly, minus the plumb bob. The leveling steps assume that the theodolite is mounted either in a permanent location or upon a tripod which can be erected anywhere. To begin leveling, point the telescope straight up and engage the elevation tangent screw to prevent movement. Lower the battery box. This acts as a counterbalance to the eyepiece. Set the azimuth scale at 0° and engage the azimuth tangent screw. Mark the point at which the plumb bob comes to rest. The plumb bob is used with the tripod only and is fastened to the center cap at the base of the theodolite. Now you are ready for leveling.

1-7. Loosen the lower clamp wing screw (fig. 1), allowing free rotation of the theodolite. Rotate the theodolite until each bubble level parallels a pair of diagonally opposite leveling screws, as in figure 2. Then tighten the lower clamp. Look at one of the bubble levels. If it is nearly centered, spend no time bringing the bubble exactly to center until the other bubble is nearly centered. When you need to level, turn the diagonally opposite leveling screws in opposite directions. To illustrate this further, your thumbs move either toward or away from each other as you turn the leveling screws. Do this to each set of diagonally opposite leveling screws until the affected bubble is exactly centered. After leveling, you must tighten the leveling screws to the same degree of tightness. This prevents shifting or tipping of the base plate. These leveling steps were made at 0° azimuth. Disengage the azimuth tangent screw, turn the instrument to 180° azimuth, and note the position of the bubbles. If they remain centered, your theodolite is level. Off-center bubbles require leveling to be done at 180° azimuth. The bubbles should, of course, remain centered during a full rotation of the theodolite. It is quite possible that after leveling at 180°, you will find the bubbles are off-center at 0°. That indicates a needed adjustment of the theodolite vertical axis. This next paragraph discusses how to make such an adjustment.

1-8. Level one of the bubbles at 0° azimuth. Rotate the instrument to 180° and correct one-half of the bubble displacement by using the leveling screws. Correct the remaining bubble displacement by raising or lowering the adjustable end of the level. There is an adjusting screw for that purpose. Repeat these steps for the other level. When you are satisfied that the theodolite remains level, check the plumb bob to see that it has not moved from the mark. This check becomes important to accurate orientation toward true north when the observation site is permanently located. A permanent site has a fixed mark over which the plumb bob must be suspended. The orientation of the theodolite centers upon that plumb bob mark.

1-9. *Orienting*. The method by which you align 0° on the theodolite azimuth scale with true north represents the second major adjustment. You can locate true north by sighting certain stars or the sun as reference points. A method using the magnetic compass, though less precise than either star or sun orienting, represents a third way you can locate true north. Naturally, any site chosen as the point of observation has to be regarded with respect to obstructions that would interrupt tracking the pibal. Tall buildings, towers, trees, and smokestacks close to the tracking site seriously limit tracking at low-elevation angles. Ideally, obstructions should not hamper tracking above an elevation angle greater than 6°. If a single observation site cannot satisfy this view from all directions, perhaps a second observation site could be established. Careful selection of the second site could eliminate or reduce the structural interference to tracking that exists at the first site. Each official observation site receives orientation to true north. Once oriented, datum lines (lines of orientation) simplify the locating of true north thereafter.

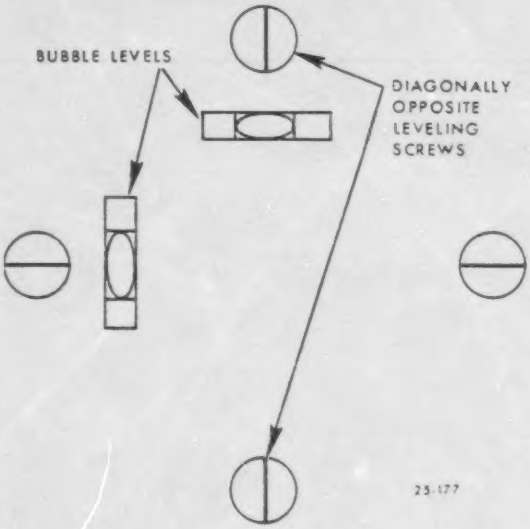


Figure 2. Theodolite leveling screw arrangement.

1-10. Any nearby electrical motor or mass of iron or steel affects the alinement of a magnetic compass. Therefore, you must consider magnetic influences when choosing a site for compass orienting. Some theodolites come equipped with a compass for orienting. Though other composes could do the job, only this compass is considered in our discussion.

1-11. A discussion of the comparison between true and magnetic north is not new to you. You have faced this relationship with wind direction measuring equipment. As with wind, the difference between true and magnetic north at your location becomes a prime piece of information. This difference, or declination, can be obtained from an aeronautical chart or topographic map. As you know, declination is expressed as easterly or westerly. The rule reads as follows: to obtain a true north, *add* easterly declination to magnetic north and subtract westerly from magnetic north. Steps for orienting are simple.

1-12. First, level the instrument. Set the azimuth scale mark for the amount of declination. Using a declination of 10° as an example, you would set 10° easterly at 10° on the azimuth scale. Set 10° westerly at 350° on the azimuth. Hold this setting constant as you turn the instrument to line the compass needle with S. You make this turning motion by operating the slow-motion screw of the lower clamp. If a large movement is needed, loosen the lower clamp and turn the theodolite instead of tediously turning the slow motion screw. When you have obtained declination and compass settings, you have oriented the theodolite. If it is likely that the same observation point can be used for other pibals, establish datum lines.

1-13. Datum lines act as orienting lines through you use of fixed landmarks. After a compass or celestial orientation, select a prominent, fixed landmark about 100 feet away and center the crosshairs upon that point. You must sight the telescope upon that point by using the azimuth tangent screw and not by loosening the lower clamp. The point selected for sighting should be precise enough to avoid a variation of azimuth when the crosshairs are centered. Record the elevation and azimuth angles with a detailed description of the point selected. Choose a second and third datum point, if available. To orient from a datum line, you set the azimuth angle of the datum point, loosen the lower clamp, center the datum point at the crosshairs, tighten the lower clamp and make the fine adjustment with the slow-motion screw. Whether you use compass orienting, sun, or star referencing intially, the datum line remains as an acceptable method for subsequent observations from the same site.

1-14. When you orient by the sun, you use exactly 12:00 noon, solar time, because the sun passes directly above the meridian (longitude) upon which you stand. That meridian, as do all meridians, passes through true north. If you could determine the difference between true solar time and local meridian time, a fix of the sun at solar noon would point to true north. Determining the time difference involves two steps.

1-15. As you know, each time zone spans either side of a standard meridian. The local standard time for any zone is figured at the standard meridian. For the first step, you must know the difference between true solar time and the local standard time. Fortunately, an equation of time graph, figure 3, supplies this difference. From the graph, you obtain a correction, in minutes, to apply to solar time to find local standard time. On May 11, for example, solar noon occurs at 1156 local standard time. The graph yields a correction of −4 minutes which, when subtracted from solar noon, gives the local standard time. For convenience, install an equation of time graph in the theodolite carrying case. You can see the difficulty of obtaining corrections in parts of a minute from the graph. For a more precise comparison between solar and local standard time, consult the *Air Almanac*. This almanac, issued quarterly by the United States Naval Observatory, is available through the Government Printing Office. The almanac compares local time with solar time for every 10 minutes of each date of the year. Finding the data is relatively easy. Appendix A contains sample pages from the almanac.

1-16. Turn to the page in the almanac listing the date you need. Local time is found in the GMT column. Do not let the difference between your local time and Greenwich time concern you. The comparison between local and solar time does not depend upon your local time. Any local time—Greenwich, for instance—will do. Referring again to the almanac, 1200 GMT, local noon, has a corresponding GHA of the sun in the second column. Greenwich hour angle (GHA) gives the exact meridian of the sun. From the sample page in Appendix A, notice that at 1200 local noon on April 30 the sun is directly over the 0°42′ meridian. However, you are located at 0° (Greenwich) in this example. Then convert the 42′ of distance to time and you arrive at the difference between local noon and your solar noon. Appendix B provides a convenient method for conversion. In the body of the table, find 0°42′. The corresponding time is 2 minutes and 48 seconds. Apparently the sun crossed the 0° meridian 2 minutes and 48 seconds be-

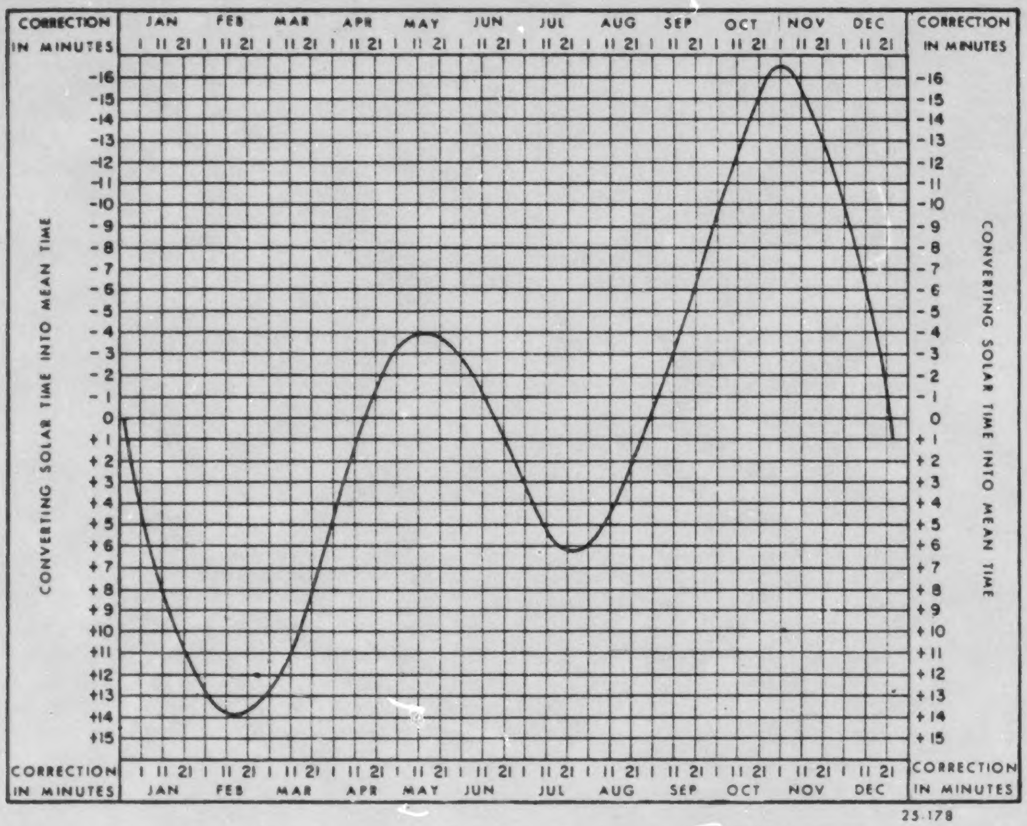


Figure 3. Equation of time graph.

fore local noon, or at 11:57:12. Comparing the equation of time graph for the same date yields approximately a −3-minute correction. In other words, subtract 3 minutes from solar time to obtain local time.

1-17. The graph is accurate enough for most orienting purposes. The almanac reference is made so that you have a second method of deriving the difference between true solar time and local standard time. Almanac data is obviously more accurate. Returning to the problem of determining the difference between true solar time and standard meridian time, we have completed step 1. We know the difference between solar and standard meridian time. Step 2 finds the amount of time difference between the standard meridian of the time zone and your position, the local meridian.

1-18. Each degree of difference in longitude amounts to 4 minutes of elapsed time. *Subtract* the time from local standard if you are located east of the standard meridian. *Add* for a *westerly* position. Keep in mind that the reference to east or west is with respect to the standard meridian of *your particular time zone* and not to the Greenwich meridian. The result of this last computation gives you the local time at which the sun passes directly over your meridian. If you set the 180° azimuth of the theodolite toward the sun at the precise moment of passage, you achieve orientation. Before detailing the remaining orientation steps, let's summarize for a moment the two steps in finding solar noon.

1-19. Suppose the current date is September 24. Your station's longitude is 88°101W. Today, at solar noon, you wish to take a fix of the sun for theodolite orienting. Consult the equation of time graphs (fig. 3) for September 24. The time correction obtained is −7 minutes, or 11:53 local standard time. That is the time at the standard meridian, or 90°. You are at 88°, or 2° east of 90°. Your location causes an 8-minute correction (4 minutes for each 1 degree) to be subtracted from 11:53. Solar noon occurs, then, at 11:45 on that date. Obviously, accurate time plays an important part in sun orienting. You may find that working to the nearest minute affords inadequate accuracy and that more exact timing is necessary. For this purpose, the *Air Almanac* tables prove useful.

Now that you have determined true solar noon, prepare for the final orienting steps.

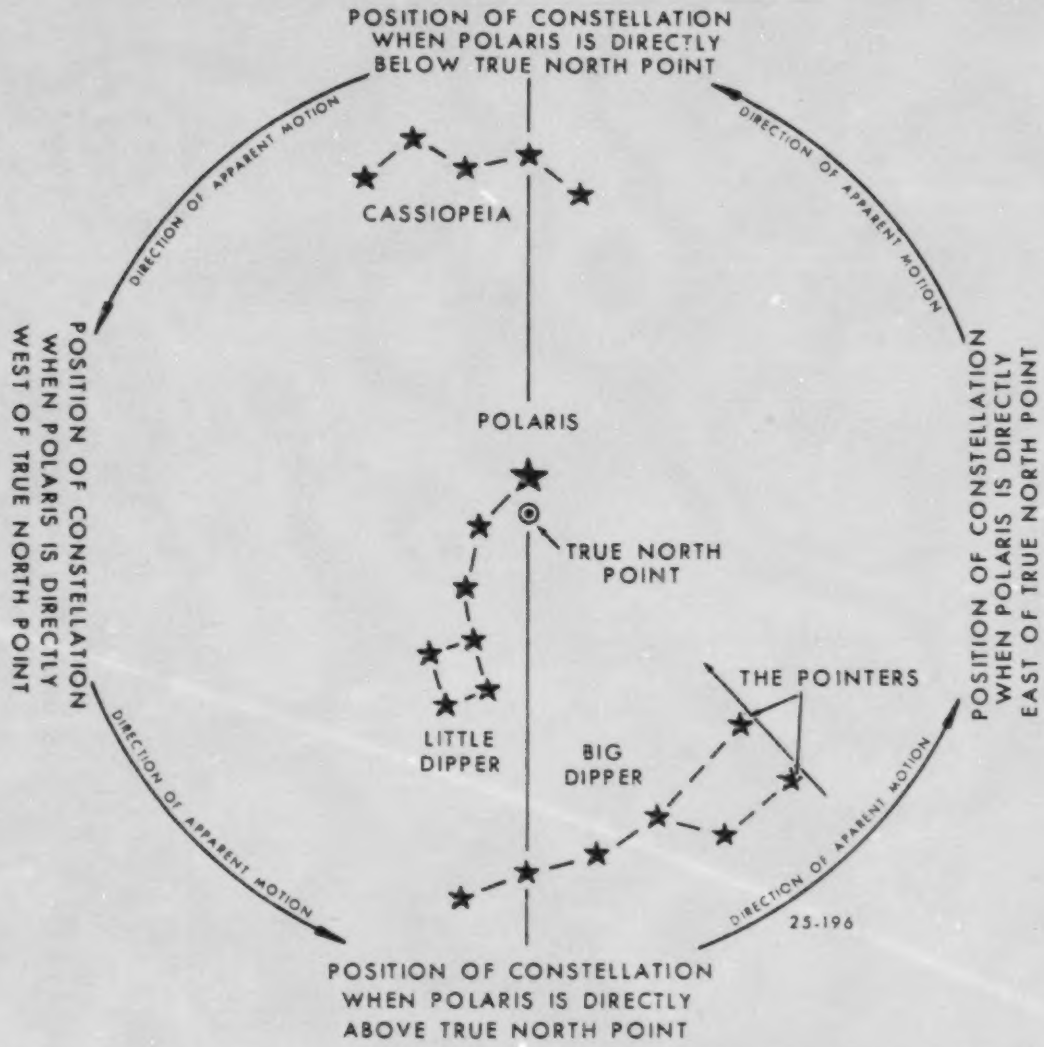
1-20. Level the instrument and cover the telescope lens with a dark ultra-violet light filter. *Permanent eye damage can result from ignoring this safety precaution.* Set the azimuth scale at 180° and leave the tangent screw meshed. Loosen the lower clamp and sight the telescope on the sun several minutes before true solar noon occurs. Aim the scope so that the sun appears to both sit upon the horizontal crosshair and straddle the vertical crosshair. About a minute before noon, tighten the lower clamp and use the slow-motion screw to follow the sun's passage. At the moment of true solar noon, stop turning the screw—the theodolite is oriented. Establish datum lines for future orienting.

1-21. Two major limitations of sun orienting are apparent. First, establishing true solar noon without the proper tables for accurate computation becomes a vague estimation at best. Secondly, due to the size of the sun, accurate crosshair sighting again is an estimation. Clouds hiding the sun are not a major limitation since orienting, after the first time, is by datum line. If the major disadvantages of sun orienting can be minimized, this method offers greater accuracy than magnetic compass orienting. A third method eliminates the time calculations, astronomical tables, and related arithmetic. However, it too has a disadvantage, because it relies on two sets of observations taken several hours apart. This method is called *equal angle*.

1-22. To an observer in the Northern Hemisphere, all the stars (including Polaris, the North Star, shown in figure 4) appear to rotate counterclockwise about the north celestial pole (true north). Polaris' circle of rotation is small at low and middle latitudes, but exceeds 3° above the Arctic Circle. Polaris, then, is too flexible to serve as an orienting fix. The equal angle principle is basically simple. It presumes that if observations are made on a star as it ascends in the eastern sky and again at the same elevation when it descends in the western sky, *the midpoint between the two azimuth angles is due north of the observation point.* That says a lot, but the illustration in figure 5 points out the simplicity. Observe the star as it ascends, point A. Some time later, and as the star is apparently descending in the west, observe it again, point B. The elevation angle of the star at points A and B must be equal. These two observations furnish azimuth readings for points A and B. Now, if you take ½ of the angle formed by OA and OB, the azimuth along line ON points to true north. Let us examine the steps of equal angle orienting in detail.

1-23. As always, level the theodolite and set the azimuth scale at 0.0°. Without disturbing that setting, sight upon an easily visible reference point. You have to loosen the lower clamp to do this, and tighten it again when you are through. This reference point serves as a starting line. Since you have not yet located north, the reference point acts as a substitute. *This reference point becomes important in the final orientation step.* Once you locate north, you can make the angular adjustment from reference point to true north easily. Select a prominent star to observe—one that is bright enough to be clearly visible, and also not easily mistaken for another nearby star. In addition, choose a star not too close to either the horizon or the zenith. Take three sightings of that star at about 15- to 30-minute intervals, recording the azimuth and elevation angles at each sighting. Record angles to nearest .01° by careful estimation. Repeat the sightings on the star's downward passage at exactly the same elevation angles. Determine the *midpoint* of the azimuths for each pair of elevation angles. To illustrate, suppose that the first fix at 28° elevation yielded an azimuth of 238.32° and that the second sighting at 28° gave a 193.45° bearing. The midpoint of these two sightings is at 215.88°. Eventually, you compute three midpoints which, when averaged, result in the azimuth most closely representing true north. One more step remains. Adjust the azimuth of the reference point by subtracting the midpoint bearing from 360°. The result gives you the true azimuth of the reference point that you used as a true north substitute earlier. Now you can set the azimuth scale at that bearing, lock it in place, loosen the lower clamp, sight upon the reference point, tighten the lower clamp, and true north orientation is completed.

1-24. Equal angle orienting need not be confined to starsighting. The sun may also be observed in this way. If so, position the sun in the morning sightings to the upper left of the crosshairs, and to upper right in the afternoon. The crosshairs should be tangent (next to) to the edge of the sun. Though equal angle orienting requires a longer span of time over other methods, it can be done in the field without benefit of astronomical tables, accurate timepieces, or knowledge of the local meridian. You must be reasonably careful with your computations, especially when figuring midpoint between azimuths on either side of 360°, such as 348° and 24°. Woe to your orienting if you compute the midpoint in this case as 186° instead of 6°. You must also be cautious to observe the same star for all the sightings. Nothing in the orienting steps can reveal to you an accidental


POSITION OF CONSTELLATION WHEN POLARIS IS DIRECTLY BELOW TRUE NORTH POINT
DIRECTION OF APPARENT MOTION
DIRECTION OF APPARENT MOTION
CASSIOPEIA
POSITION OF CONSTELLATION WHEN POLARIS IS DIRECTLY WEST OF TRUE NORTH POINT
POLARIS
TRUE NORTH POINT
POSITION OF CONSTELLATION WHEN POLARIS IS DIRECTLY EAST OF TRUE NORTH POINT
THE POINTERS
LITTLE DIPPER
BIG DIPPER
DIRECTION OF APPARENT MOTION
DIRECTION OF APPARENT MOTION
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POSITION OF CONSTELLATION WHEN POLARIS IS DIRECTLY ABOVE TRUE NORTH POINT

Figure 4. Polaris (North Star).

wrong star sighting. After leveling and orienting the theodolite, you are prepared to inflate and release the balloon.

1-25. **Balloon Preparation.** One of the characteristics of a pibal observation is a balloon ascension rate that is assumed rather than measured. To be able to assume an ascension rate, a fixed amount of lift must be given to the balloon. The lifting force depends upon the size of balloon, the amount of bouyant gas used, and attachments to the flight train. Because of these variables, inflation of the balloon must be carefully regulated.

1-26. *Types of balloons.* Two sizes of balloons are currently used: the 30-gram and the 100-gram. When pibal observations are given altitude requirements of 15,000 feet or less above surface, the 30-gram balloon can be used. Use the 100-gram balloon for higher altitude requirements or when you suspect the 30-gram balloon would be lost from sight before reaching the desired altitude. Handle the balloons carefully by the neck portion, because their delicate construction cannot stand abuse. Balloons that have been stored for a long time lose their elasticity. Recommended storage is in the original container in a warm room. Where balloons are subjected to below-freezing storage temperatures, return them to a 65° F. or higher temperature before using. Immersion in warm water for several minutes conditions the balloon's elasticity. Allow no water to enter the balloon and dry the outside before inflation. You may choose from white, black, or red colored balloons to suit your need.

In general, the white balloon is most visible against a clear sky, red or black against an overcast. Several methods are available for inflating the balloon, but your choice is limited to whichever method your base provides.

1-27. *Inflation methods.* Either helium or hydrogen gas provides the lift. Of the two, helium is more desirable because it can be easily stored and is not flammable. Hydrogen requires careful storage, or must be generated for immediate use, and has the discomforting and dangerous quality of being flammable. Whichever gas you use determines the amount of counterweights to attach during inflation. A table of pilot balloon inflation nozzles and weights in Circular 0 gives the weight to use with either gas. Suppose you wish to fill a 100-gram balloon with helium, using an ML–575 nozzle for the purpose of taking a daytime pibal. The table reveals that 470 grams of weight are to be attached during inflation to give the balloon the proper lift. The fixed rate of ascension for a pibal, therefore, depends entirely upon the correct attachment of counterweights during inflation. If a lighting unit and parachute are included in the flight train, the table gives weights for them. Upon selecting the correct weights, remove any excess air from the balloon before placing it on the inflation nozzle. If inflating with helium, fill the balloon slowly from the cylinder until the balloon and its attached weights float. You should hold the inflation hose up so that its weight will not seem to be part of the inflation weight. Slow inflation avoids shooting the balloon off the nozzle and also allows the thin-walled balloon to adjust to the increased pressure upon it. Listen for balloon leaks before tying the neck of the balloon with a soft cord. Inflate the balloon just before its release to minimize chances of its accidental bursting on the ground.

1-28. **Pibal Release and Tracking.** A prerelease check of the theodolite and the timing device used during tracking may reveal problems that would not permit an observation. Therefore, balloon inflation becomes the last step before release. Release times, as far as possible, should conform to scheduled upper winds observations times. Naturally, your goal is to attain the required altitude or at least exceed the minimum requirements for a second release. A pibal need not be taken if a low cloud ceiling would prevent the observation from reaching 3000 feet above the surface unless the observation is requested because of a severe weather forecast and unless winds at 1000 feet can be attained. A second release may be necessary if you obtain less than 10 minutes of data and more could have been observed. Obviously, if a cloud base or obstruction prohibits a second release from reaching beyond the first release, do not repeat the pibal. Also, strong winds may drive the balloon out of sight horizontally, rendering a second release undesirable.

1-29. *Release procedures.* Release the balloon as near as is practical to the theodolite height and site. This is a convenience rather than a requirement, because for some releases, a little

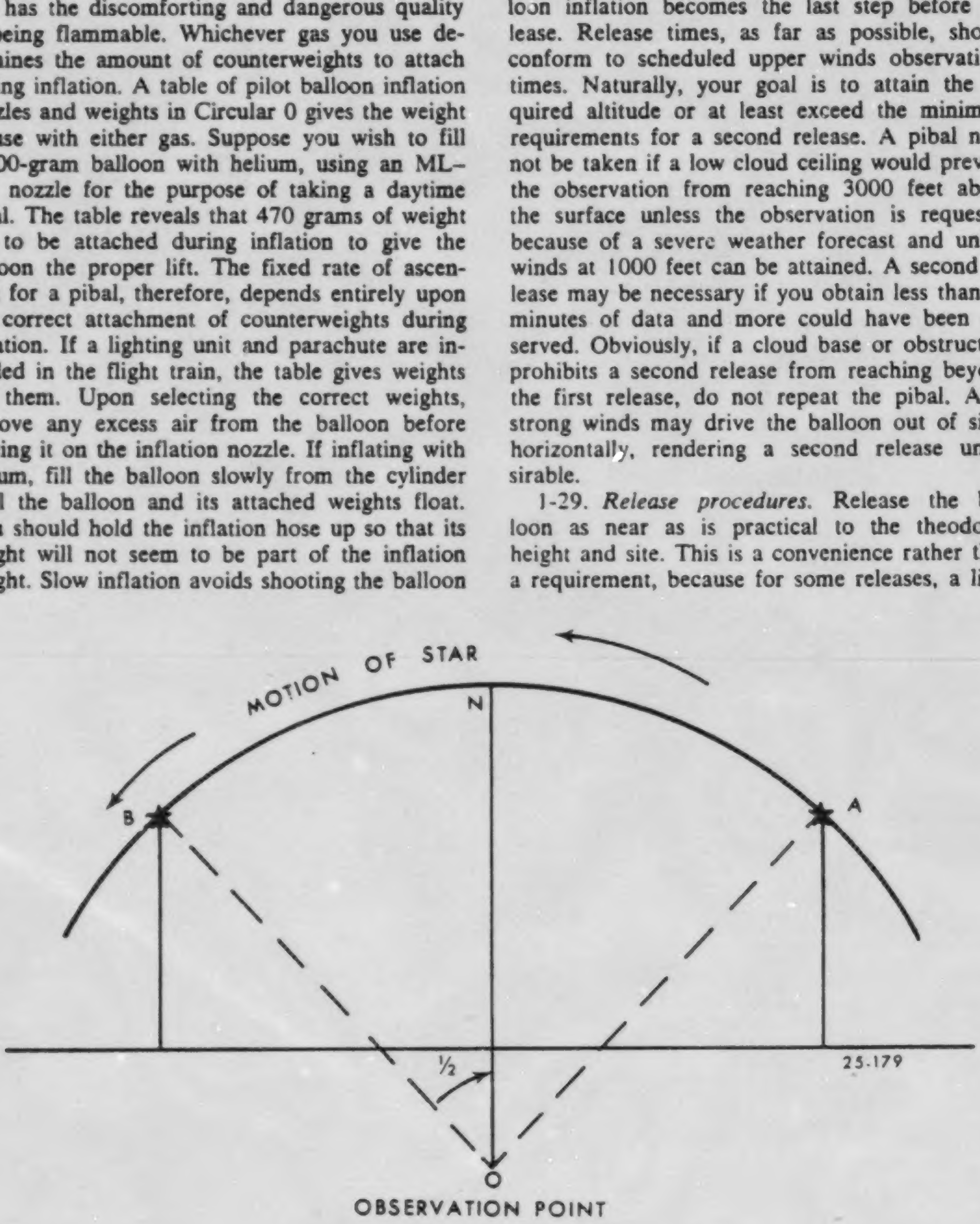

Figure 5. Equal angle orienting example.

distance between theodolite and balloon release is desirable. Take a surface wind observation at the release site. At the moment of release, the timing device must also be started. This device can be a stopwatch, watch, or the ML–110 timing set. The ML–110 provides two-way telephone communication between the observer and a remotely located plotter in addition to the timing signal. Whichever timing method you use, the "read" signal should be preceded by a "warning" signal 5 or 10 seconds before each minute. This alerts the observer to maintain the crosshairs on the balloon. The ML–110 timing set gives a 7-second warning.

1-30. As the balloon becomes airborne, the observer attempts to sight it with the theodolite. At first, this may prove difficult because of the large angular changes which the balloon makes from the observation site. During these first moments, follow the balloon with the gunsights rather than with the telescope. Also, for ease of movement, you may want to unmesh the azimuth and elevation tangent screws. One of the hardest ascensions to follow is the one that rises directly overhead. Even sighting with the gunsights is difficult because of the awkward angle. If you expect the balloon to rise directly overhead, release the balloon at a convenient distance from the theodolite. Following the balloon with the gunsight is a temporary measure until the balloon can be located and followed by either the auxiliary or main scope. By the time the first minute after release arrives, the balloon should be in the field of one of the scopes.

1-31. *Tracking procedures.* Tracking settles down to a succession of angular readings taken each minute. The observer keeps the balloon within the field of the scope; and, when the warning signal is given, he centers the crosshairs upon the balloon. At the "read" signal, all scope movement should stop while the azimuth and elevation angles are noted. Continue tracking by turning the tangent screws until the next minute. You need not keep the crosshairs centered continuously on the balloon. However, the balloon should never be allowed to leave the field of the scope. This is sometimes easier said than done. Special caution during tracking has to be exercised when precipitation, strong winds aloft, obstructions in field of view, sun interference, and cloud structures hide the balloon or make tracking difficult.

1-32. Difficulties encountered during tracking may cause you to lose the balloon momentarily. Do not stop searching until 5 minutes have elapsed. A pibal must not contain more than 5 consecutive minutes of missing data. Drizzle or light rain makes tracking difficult by wetting the telescope lens. Though the scope shield offers some protection to the lens, moisture on the lens often cannot be avoided. Heavy precipitation or hail, sleet, and freezing rain have a marked effect on the balloon's ascension rate, causing an inaccurate assumption of upper winds.

1-33. Strong winds aloft make tracking difficult by moving the balloon rapidly. A swiftly moving balloon requires that you have agile fingers to turn the tangent screws and keep the balloon within the narrow field of view on the main scope. A wind shear aloft may shift the balloon's direction of movement in a radical manner. Nevertheless, whenever possible, lead the balloon as you would lead a moving target with a rifle. Often, leading the balloon becomes necessary when it passes behind a fixed obstruction.

1-34. Judge the balloon's path behind the fixed obstruction. The balloon's movement just before disappearing can guide your judgment. Move the scope to the spot at which you expect the balloon to reappear and disengage the elevation tangent screw. Manually swing the scope up and down through a short arc, scanning for the first glimpse of the balloon.

1-35. Tracking the balloon across the sun's brightness is not easy either. Naturally, you do not wish to focus the sun's rays through the scope into your eye. ALWAYS be careful of your eyes when tracking. The alternative is to judge the path of the balloon and pick it up on the other side, as with a fixed obstruction. Cloud elements may also obstruct your view of the balloon. Leading the balloon through a cloud may prove hard to do because the cloud, too, is moving. Because of this, the balloon may reappear from a totally different portion of the cloud than you might expect. Whenever you lose the balloon from view, search in a systematic manner. If the balloon is low enough to see with the unaided eye, use the gunsight to aim the scope at the expected appearance point. At higher balloon elevations, your search may be more complicated.

1-36. First, search the portion of sky where you judge the balloon should be, according to past position. If this fails, your natural suspicion is that the balloon has altered its movement. Though logical scanning methods may vary from situation to situation, a good method is to scan perpendicularly to the last known path. Consider a situation where the balloon's path is increasing in elevation more than azimuth. A perpendicular scan is to select an elevation and make short scanning swings back and forth through several degrees of azimuth. If this scan is unsuccessful, change the elevation angle slightly and repeat the scanning. When scanning, swing the scope slowly, so that you won't pass the balloon without seeing it. Remain calm if the balloon is lost from view. Usually, it has not gone very far from the point where you last saw it. Wild, frantic scanning soon leads you away from the most probable position and lengthens the time the balloon remains lost.

1-37. Your objective during tracking the balloon revolves around collecting azimuth and elevation readings for each minute of ascent. Read each azimuth and elevation angle to the nearest one-tenth degree (0.1°) except when the angle of elevation becomes less than 15°. At elevation angles less than 15°, make elevation readings to the nearest 0.05°. Continue to observe azimuth to 0.1°. Take as little time as possible to read the scales, especially when either angle is changing rapidly. It is unnecessary to let scale reading cause you to lose sight of the balloon. You can read a rapidly changing angle first and follow the balloon through its rapid motion in that angle before reading the other angle. Take care to make the slower angle reading before changing its setting. Plot each angular reading and measure it for speed and direction. Before turning our attention to plotting pibal data, we shall make a few remarks about terminating the observation.

1-38. The best time for a preliminary check of the accuracy of the observation is at termination. If this check reveals a serious error, a second release can be made before too much time and plotting is spent upon an unreliable observation. Check the elevation data for improper ascension rate. A leaking balloon shows up as a noticeable decrease in the elevation angle. Do not assume that a decreasing elevation angle always indicates a leaking balloon, however. A layer of strong winds also causes elevation readings to decrease. Elevation decreases due to a leaking balloon are more pronounced. Also, the observation tends to be *longer* than normal. Questionable pibal data can be evaluated and transmitted; but if a second verifying pibal is possible, it should be made. The verifying pibal must be made within the time limits specified for observing upper winds. When two observers take a pibal observation, the evaluation usually is finished soon after termination of the ascent. One man can easily plot and evaluate the data as it is obtained.

2. Plotting and Measuring

2-1. The observed elevation and azimuth angles are recorded by the plotter. His task is to convert these angles into a minute-by-minute picture of the direction the balloon took, and the horizontal distance out (HDO) it travelled from the release site. Using this plotted picture and specially constructed scales, he may derive windspeed and direction for each minute. Then he plots the speeds and directions on a graphing board to construct continuous curves from surface to termination. Windspeed and direction can easily be extracted from the graphed curves for any height interval desired.

2-2. From the foregoing overview of pibal plotting, you can see the basic simplicity of this task. It is the details of plotting which tend to make it appear more complicated.

2-3. **Pibal Plotting.** Two plotting sets are available for pibal plotting; either may be used. The A–1 plotting set permits a direct plot of observed elevation and azimuth angles. Also, it accommodates an HDO of approximately 150 miles, enough distance for even an extraordinarily successful pibal. The other plotting set, ML–122, has almost a 10-mile HDO scale, which frequently proves to be too short. Distances beyond the scale limits must be divided by a known factor (2, 4, etc.) before plotting. The short HDO of the ML–122 constitutes an inconvenience rather than a serious limitation. Another feature of the ML–122 is that elevation angles are not plotted. They are converted to HDO from a set of tables. Let's examine the plotting steps of the A–1 set.

2-4. *A–1 plotting set.* The A–1 set consists of two plotting boards. (See fig. 6.) A circular board with 360° of azimuth allows a plotted HDO of 7 km. The full circle azimuth provides a convenience in plotting balloon direction shortly after release. Until the steadier upper winds influence the balloon, it may prove through the full circle. Referring to the small auxiliary board in figure 6, let's examine the plotting procedures.

Step 1. Aline the small plastic plotting arm with the *elevation angle.*

Step 2. At the intersection of the plotting arm with the *vertical height scale,* make a *1* mark on the board and number it "1" for the first minute. (WBAN 20 gives the pibal heights in meters.)

Step 3. Plot and number succeeding minutes in a similar way until you reach the edge of the auxiliary board.

Step 4. Place the plastic plotting arm along the *horizontal distance (HDO) scale.*

Step 5. Transfer each plotted mark (in step 3) from the board to the plotting arm by bringing them down vertically. *(The transferred marks are now HDOs.)*

Step 6. Erase the plotted marks on the board after transfer to the plotting arm.

Step 7. Aline the marked edge of the plotting arm with the azimuth angle of the first minute and transfer the first mark on the plotting arm directly to the board and number the mark.

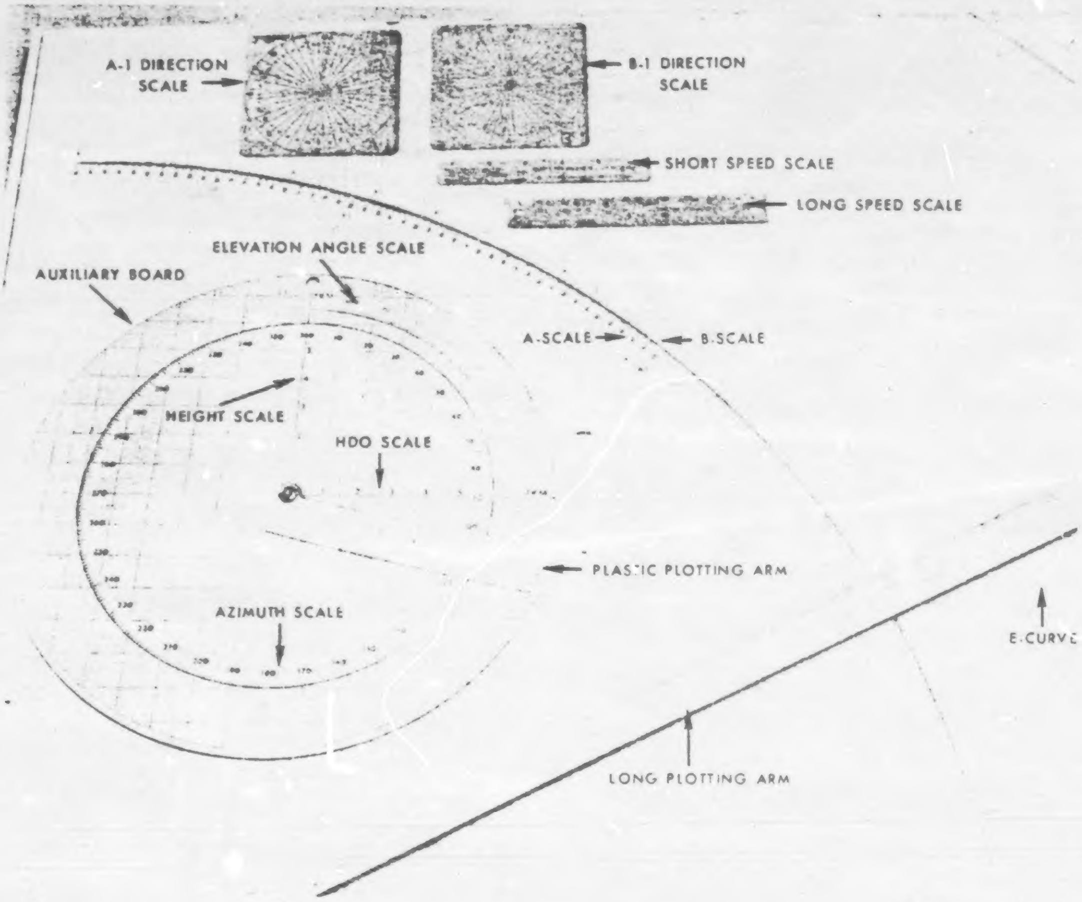
A-1 DIRECTION SCALE
B-1 DIRECTION SCALE
SHORT SPEED SCALE
LONG SPEED SCALE
ELEVATION ANGLE SCALE
AUXILIARY BOARD
A-SCALE
B-SCALE
HEIGHT SCALE
HDO SCALE
PLASTIC PLOTTING ARM
AZIMUTH SCALE
E-CURVE
LONG PLOTTING ARM
25.180

Figure 6. A–1 plotting set.

(This positions the balloon with respect to direction and distance from the station.)

Step 8. Repeat step 7 for each succeeding minute. Using speed and direction scales, you can read the upper winds from the plotted points. A discussion of this comes later. Consider, first, the plotting on the big board of the A–1 set.

2-5. Having plotted as many minutes as the auxiliary board permits, you continue the plotting upon the large A–1 board. Imagine the large board as an expanded section of the auxiliary board. The plotting steps are similar. Either the A or the B scale may be used for plotting *elevation*. For angles 45° or above, use the A scale. Figure 6 shows these elevation angles already numbered. The B scale accommodates the lower elevations. After marking the HDO on the plotting arm, the A scale then acts as an *azimuth* scale. However, you must number the A scale for azimuth to suit the needs of your observation. The elevation numbering, for this purpose, may be ignored. You are free to assign the A scale any 90° segment of the azimuth circle. Less crowding of the HDO plots results if you keep the plotting along the bottom edge of the board. Your scale may be numbered clockwise or counterclockwise. Though it is not absolutely necessary, you are sure to find it more convenient to begin numbering the A scale with one of the 8 points of the compass rose. When you begin to read directions from your plotting, you will be glad you did. Proceed to transfer the HDO marks back to the board according to the chosen azimuth scale. To make a smooth transition from the auxiliary to the main board, replot the last two points from the auxiliary board. Later, when you read speed and direction, the reason for this becomes clear.

2-6. One more plotting point needs to be mentioned. An E-curve on the main plotting board separates the plots *needing* an earth curvature correction from those *not needing* a correction. E-curve corrections apply only during the elevation plotting. If the elevation angle becomes low enough to cast the plotted points below the E-curve, a small correction must be applied to the elevations before you plot. In the portion of the board bounded by the E- and A-curves, shown in figure 6 at bottom center, the correction amounts to 0.2° elevation *added to the observer angle*. Beyond the A-curve, add 0.4°. Larger corrections are added beyond the outer scales (c and B¹), but they are unlikely to apply to pibal observation.

2-7. For convenience in plotting short observations, such as a pibal, the A–1 set comes equipped with a short plotting arm. The plotting arms are a magnesium alloy which takes a dark pencil mark quite easily. However, the marks can easily be smudged or rubbed off. Use care in handling the plotting arm after the HDOs are put on it. Put aside in your mind, for a moment, the A–1 set procedures and shift your attention to the plotting steps of the ML–122.

2-8. *ML–122 plotting set.* This plotting board has just one scale—azimuth, as shown in figure 7. The plotting arm, ML–126, is graduated in yards for plotting the HDO. Each mark represents 50 yards. With no elevation scale available, you must use another method for finding HDO. A set of HDO tables takes care of this problem. AWS Technical Report 105–116 computes HDO for a 30-gram balloon, and AWSTR 105–117 computes for a 100-gram balloon. The tables list the HDO in meters for elevations 0.0° to 89.9° by 1-minute intervals. For each minute of balloon observation, you simply enter the table with the elevation angle for that minute. Then use the ML–126 plotting arm to plot the resulting HDOs on the ML–122 board. With the ML–126 pointed at the proper azimuth, find the HDO on its scale and make a */* on the board. Number the mark for the minute it represents. Though you are plotting meters from the HDO tables against yards calibrated on the rule, the difference in scale is unimportant. In other words, the marks on the rule can be considered as meters. More important to the final product is that if you plot distances in meters, extract speeds in meters per second. No other plotting steps are necessary.

2-9. Unfortunately, the short HDO scale on the ML–126 frequently makes it necssary to extend the scale by mathematical means. That is to say, by dividing HDOs beyond 17,000 meters with a known factor (2 or 4, for example), you bring the plotting back within the length of the rule. Naturally, the factored plots must be kept separate from the others. A good habit to develop is to read speed and direction from the

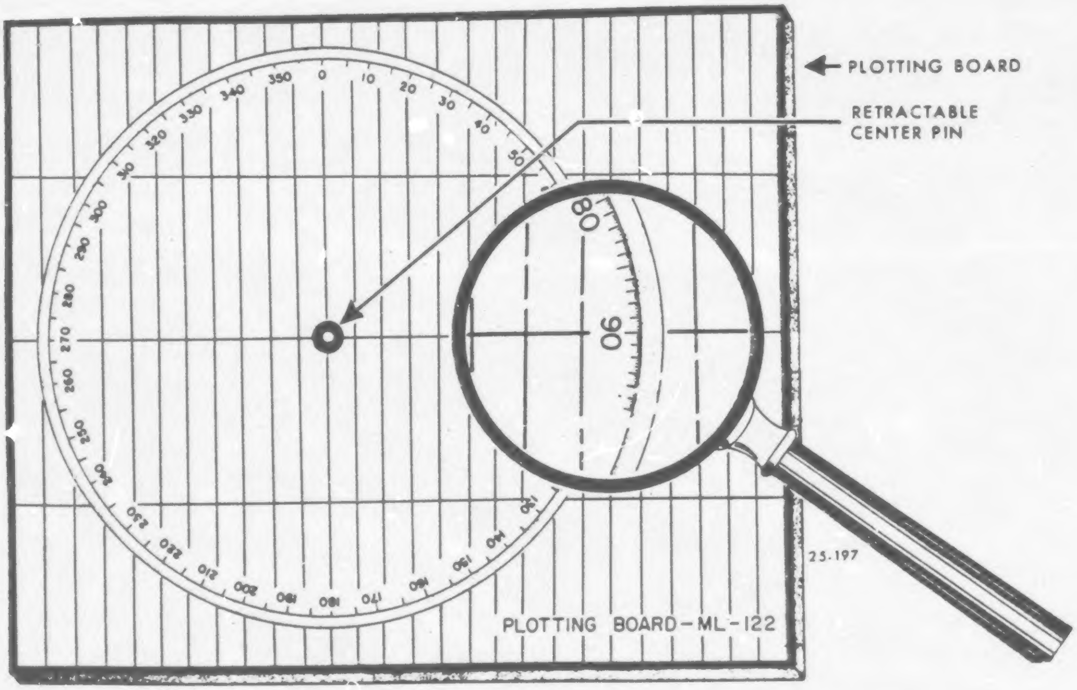

Figure 7. ML–122 plotting set.

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unfactored plotting, erase it, and then plot the factored HDOs. This method may also help you to remember that windspeeds are multiplied by the same factor you used to plot. Plotting observed data on either the A–1 or ML–122 sets presents no difficult challenge. Before turning to the plotting rules, you need to determine what to do with missing data.

2-10. *Missing data.* When angular readings have been missed for *not more than 3 consecutive minutes,* draw a smooth curve on the plotting board through the three points just before and another curve through the three points following the missing stratum. Interpolate between both of these two segments to form a smooth continuous curve. On the curve through the missing stratum, plot points for the missing minutes to form a reasonable picture of the balloon direction and speed. Interpolation *cannot* be extended to 4 consecutive minutes, or cannot be used for *data missing just off surface.* Recall also from an earlier paragraph that a pibal must not contain more than 5 consecutive minutes of missing data. Now that you have examined the features of the individual plotting sets, take a look at the plotting rules.

2-11. *Plotting rules.* Every observed minute does not need to be plotted. Evaluation of windspeed and direction, especially above a height of 7 km (MSL), does not require complete plotting. To avoid plotting excessive information, these plotting rules are listed. Between surface and 7 km (7000 meters), no shortcuts are open. Every minute is to be plotted. The variable nature of winds near the surface prevents you from omitting the plots of any observed data. At 7 km, procedure changes.

a. Plot the first minute above 7 km.
b. Next, plot each odd minute.
c. Plot the first even minute immediately below 14 km.
d. Plot terminating level, if it occurs below 14 km.

These rules govern plotting until 14 km, where another set of rules takes over. Above 14 km, proceed as follows:

a. Plot the first odd minute.
b. Plot each even minute.
c. Plot the terminating minute, odd or even.

Remember the 7-km and 14-km heights are balloon heights, not HDOs. As you might suspect, the plotting rules have a bearing on the method for evaluating speed and direction. Converting plotting data to speed and direction is your next task.

2-12. **Measuring Pibal Speed and Direction.** Despite the different measuring scales used with each plotting set, certain basic rules of measurement pertain to both sets. Because not all minutes are plotted, neither are all minutes evaluated.

2-13. *Measuring speed.* Compute windspeed and direction for the following:

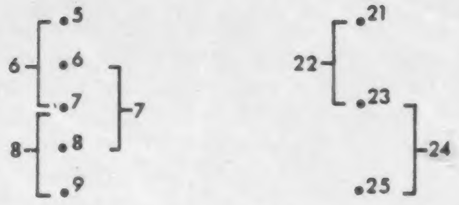
- Each minute from surface to 7 km.
- Each even minute from 7–14 km.
- Each even minute above 14 km MSL.

To find the speed and direction for the minutes specified above, measurement is patterned as shown in figure 8.

2-14. Use a 2-minute interval with a 1-minute overlap to find speeds and directions between surface and 7 km. Figure 8.A, shows that to compute for minute 6, you measure from 5 to 7. Using a 2-minute interval gives a mean wind for the layer. Between 7 and 14 km you plotted only the odd minutes, but you must find speed and direction for each even minute. Figure 8.B, shows a 2-minute interval, no overlap pattern used to extract data. Above 14 km, you plotted even minutes and must compute for even minutes. Try a 4-minute interval, 2-minute overlap (see fig. 8.C) to obtain this last measurement. These are the only basic rules pertinent to either plotting set. Take a brief look, now, at the individual plotting set speed and direction scales.

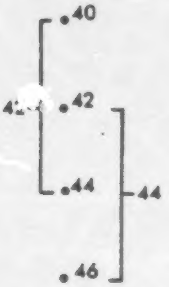
2-15. The A–1 plotting set contains two speed scales—short and long—shown in figure 6. The short scale is to be used only on the auxiliary board, and the long scale only on the main board. Normally, both scales can measure a 2-minute interval. Full scale, 4-minute intervals are read from the scale and divided by two. A full-scale plot is one which is made at an HDO less than 110 km. The speeds you get from the scales are in meters per second. There are times when, instead of a 2-minute interval, you must measure a 3-minute interval. This occurs either when the terminating minute is even between 7 and 14 km or odd above 14 km. Simply measure the 3-minute interval with your scale and divide the reading by 1.5 to obtain the speed for the required minute. Circular 0, *WBAN Manual of Winds Aloft Observations,* contains a complete summary of evaluation methods for plotted pibals. A separate scale, WPC 9–23, measures speeds plotted on the ML–122. It, too, gives speeds in meters per second for a 2-minute interval.

2-16. *Measuring direction.* Two direction scales come with the A–1 set. Only the B– direction scale can be used with the auxiliary board. The B–1 scale is constructed to match the clockwise arrangement of direction on the auxiliary board. The other scale, A–1, has the directions arranged in a counterclockwise manner. Thus, whichever way you numbered the A scale on the main plotting board, you have a direction



A. TWO MINUTE INTERVAL
ONE MINUTE OVERLAP

B. TWO MINUTE INTERVAL
NO OVERLAP



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C. FOUR MINUTE INTERVAL
TWO MINUTE OVERLAP

Figure 8. Wind measuring patterns.

scale to match. A single scale, ML–177, is used on the ML–122 plotting set. The plotting set azimuths are numbered clockwise and the one scale proves sufficient. When you measure direction, the procedure is identical on either set.

2-17. You evaluate direction across a 2- or 4-minute interval similarly to the way you measure speed. To find the first minute direction, place the center of the direction scale over the point of observation and read the position of the second minute. Successive minutes are measured by moving from plot to plot. The pattern of measuring direction resembles the speed measuring illustrated in figure 8. Foremost to keep in mind while measuring direction is the position alinement of the scale.

2-18. On the A–1 set direction scales, alinement numbers appear in small ovals every 45°. First, you must match the numbering you used on the main board A scale. If you numbered 135° at the top of the A scale and 45° at the bottom, the A–1 direction scale (CCW) matches. As you evaluate directions, in this example, maintain the 135° number always pointing to the top of the board. This keeps you within the correct segment of the direction scale.

2-19. Directions scale ML–177 does not have alinement numbers. Instead of these, it has lines that must be kept parallel to the vertical lines etched into the ML–122 itself. Unlike the A–1 scales, which are constructed as full circles, the ML–177 is only a half-circle. It resembles the protractor you use to measure degrees of an angle. Each segment of the scale has two direction numbers. Read the *larger* direction numbers when using the scale to your *right;* read the *smaller* direction numbers when using the scale to your *left.* At all times, keep the scale alined vertically.

2-20. The direction you assign to the minute being evaluated, therefore, is read directly from the scale without interpretation. Occasionally, your judgment becomes necessary when the plot falls under the line between two directions. Choose the *larger* of the two directions. Finally, when you encounter missing data, the speed and direction evaluation depends upon the extent of the missing layer.

2-21. *Evaluating missing data.* A missing layer extending no more than 3 minutes should contain interpolated plots, and you evaluate the interpolated plots. A 4- or 5-minute missing data layer should contain no interpolated plots; no evaluation can be made through a layer this deep. In this case, evaluate the last minute required before the missing layer and begin again with

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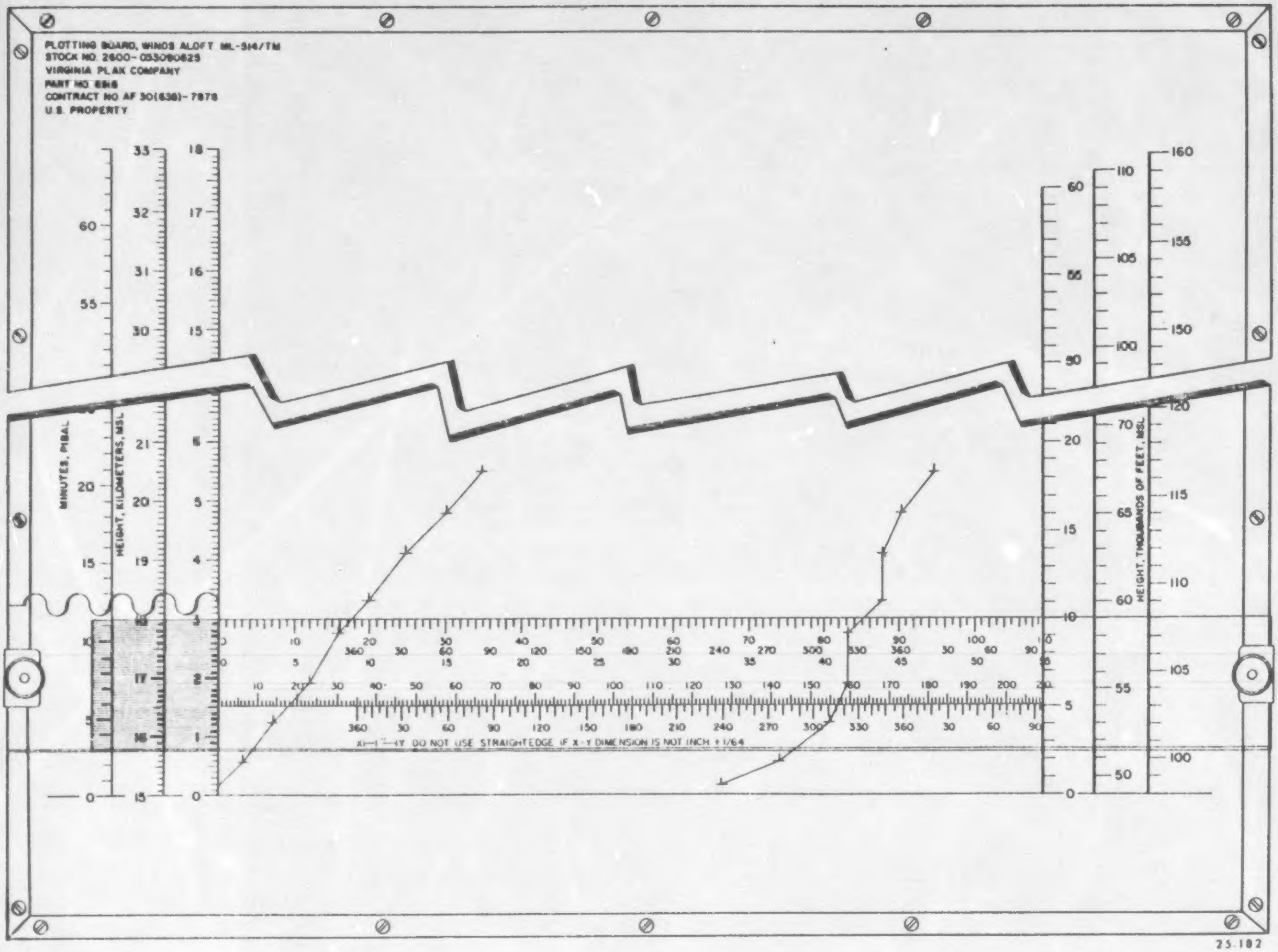
PLOTTING BOARD, WINDS ALOFT ML-514/TM
STOCK NO. 2600-033090625
VIRGINIA PLAK COMPANY
PART NO. 6816
CONTRACT NO AF 30(638)-7878
U.S. PROPERTY
MINUTES, PIBAL
HEIGHT, KILOMETERS, MSL
HEIGHT, THOUSANDS OF FEET, MSL
X—I—Y DO NOT USE STRAIGHTEDGE IF X-Y DIMENSION IS NOT INCH ± 1/64
25.182

Figure 9. ML-514/TM. Winds Aloft Plotting Board.

the first required minute following the data interruption. To evaluate the required minute, it may be necessary to measure across a 3- or 4-minute interval. This is permissible, provided the speeds are divided by 1.5 or 2. At no time should you use a 1-minute interval to determine wind data *above* altitudes of 7 km. *Below* 7 km, it is allowable. Evaluation of the plotted data for windspeed and direction is the last step involving the original observed data. From this point on, you are working with the derived speeds and directions. Before discussing further plotting steps, let us take a moment briefly to discuss the Winds Aloft Computation Sheet, AWS Form 20 (WBAN 20).

2-22. *AWS Form 20*. Write the observed elevation and azimuth angles in the columns provided. Angular readings for interpolated values are omitted. Pibal heights above surface are preprinted on the form for 30- and 100-gram balloons. The derived HDOs, speeds, and directions for each plotted minute also are filled in. Although interpolated angles and distances are omitted, windspeeds and directions are evaluated and recorded through the missing stratum. However, place brackets around the data and *label it "interpolated."* Other missing data is entered as missing for the corresponding minutes. Form 20 lists all the information, on the one side, according to minutes of ascension. The Upper Wind Code format contains wind data according to selected levels. Therefore, conversion from one basis to another remains as the final task before coding. The transfer can be made on a single graphing board, the ML–154.

2-23. Figure 9 illustrates the ML–514/TM, winds aloft plotting board. Physically, the ML–514 is a white, plastic-coated graphing board. A sliding, clear-plastic straightedge is spring-loaded to keep its left edge against the left side of the board. Both board and straightedge display printed scales for the plotting. Before plotting, check the straightedge for alinement. You can recognize proper alinement by moving the straightedge up and down and noting whether the 0-mps line coincides with the 0–18-km altitude scale during the motion. If not, correct the alinement with the adjusting screws on each end of the straightedge.

2-24. **Graphing Wind Data.** On the left side of the straightedge is a series of closely spaced horizontal lines. Beginning at the top, each line represents 25 meters of station elevation. The line that most closely approximates your station's elevation should be etched in ink. It is this inked line that you use to set the straightedge against the minute scale during the plotting and also adjust for MSL in the code.

2-25. The far left-hand scale on the board marks off the minutes of the pibal observation. To plot speed and direction for each minute, set the inked line on the straightedge to the desired minute mark. Along the top edge of the straightedge is a speed scale (meters per second). Directly below that is a direction scale in red. The result of your plotting produces two series of marks, one set for speed and the other for direction. Connect the plots and you have two curves representing the observed data. This brings you to the last step—that of coding pibal winds. A discussion of PILOT code was presented in Volume 3 of this course and needs no further explanation here.

2-26. **Encoding the Message.** Extracting the data for the required levels will offer you no obstacles. Along the right side of the plotting board are height scales in thousands of feet MSL. On the lower portion of the straight-edge appears a line on the required altitude level. From the curves, extract the speed in whole knots and direction to nearest 5°. Enter this data in the coded data columns on the legend side of AWS Form 20.

2-27. Taking a pibal observation is perhaps not as common as other methods of obtaining upper wind data. However, as an observer, you must be aware of the pibal observational method.

2-28. Before going on to Chapter 2, refer to your workbook and answer the chapter review exercise items for Chapter 1.

Rawinsonde Observations

LONGEST IN USE among electronic systems and still very important is the rawinsonde method of upper air observations. This chapter presents a view of the rawinsonde system. Topics under discussion include ground and flight equipment, preparing the sonde and balloon, and the evaluation and plotting of the several charts. All major tasks necessary in making an upper air sounding are given brief emphasis. Full proficiency in rawinsonde observing techniques, however, is not the objective. You should be able to name the steps in making a rawinsonde observation and tell how each is done. The next paragraphs introduce the chapter with the theory of rawinsonde upper air sampling.

2. The rawinsonde system allows us to evaluate wind direction and speed, temperature, pressure, and relative humidity by means of a balloon-borne radiosonde, tracked by a radio direction-finder. The radiosonde provides housing for a thermistor, hygristor, and aneroid cell. A thermistor reacts to temperature changes by changing its electrical resistance. A hygristor responds in a similar way to humidity. Actually, a moisture-sensitive chemical coating varies the resistance of the hygristor. The pressure sensing device is a small aneroid cell whose expansion acts upon a metal contact arm. This contact arm, in turn, rests upon a plastic bar called a commutator. Embedded in the commutator are narrow metal conducting strips dividing the commutator into alternately conducting and nonconducting segments. As the expanding aneroid causes the contact arm to move across the commutator, the alternating segments switch the thermistor and hygristor into the transmitted circuit. Aneroid, contact arm, and commutator make up a unit called a *baroswitch*.

3. Pressure is not directly transmitted, as are temperature and humidity. Nevertheless, a known relationship between pressure and the number of segments on the commutator makes pressure data readily available. These known comparisons come packed with the radiosonde in the form of a pressure calibration chart. You need only know the commutator segment (contact number) to find the pressure acting upon the aneroid. A wet-cell battery provides a power source for the radio transmitter. An antenna tracker follows, automatically or manually, the radiofrequency of the transmitter. As the radiosonde is tracked, azimuth and elevation angles are recorded for the plotting and computation of winds. The maximum height of the sounding depends upon the condition of the balloon and, of course, the level at which it bursts. Though the winds may carry the radiosonde several miles from a point directly above the station, the sounding is considered as a vertical sampling above the launching station.

4. Greater accuracy of pressure measurement above 100 mb results from a device called a *hypsometer*. This measures pressure at high altitudes by using the relationship between the temperature of an ebullient fluid (Freon 11) and atmospheric pressure. Radiosondes may contain hypsometer and transponder capabilities singly, in combination, or not at all.

3. Ground Equipment

3-1. Rawinsonde observing equipment is classed into two categories, ground and flight. The ground equipment must provide testing, tracking, recording and measuring of the flight equipment and its transmitted data. Three complex electronic units—the rawin set tracking unit, the radiosonde recorder, and the radiosonde check set—do all this. Our first topic is the tracking unit.

3-2. **Tracking Unit.** Rawin set, AN/GMD–2, is the heart of the ground equipment. The rawin set's main assembly should be located on open level ground free from obstructions. With clever use of radio signals, the main assembly handles positioning, ranging, and meteorological information all at the same time. The details involved in the modulation and transmission of the various electrical signals is not important to your job. Therefore, the following discussion is highly simplified.

3-3. The main assembly receives a *frequency* modulated (modified) signal from the radiosonde's transmitter. Simultaneously, temperature and humidity information is carried by the transmitter signal as an *amplitude* modulation. When the modulated radiosonde signal reaches the main assembly, it must demodulate the signal to separate the various information. Position information provides the rawin set with voltages that drive the main assembly antenna during its tracking of the radiosonde. Also, the meteorological signals are channeled to the recorder record for display.

3-4. To be accurate, the tracking unit must be oriented and leveled. This gives value to the elevation and azimuth positioning information obtained by tracking the sonde. Begin orientation by taking elevation and azimuth fixes upon a stationary radiating target. This target is a test antenna installed on a utility pole. Take the fixes by theodolite located at the spot chosen for the main assembly. After taking the fixes, replace the theodolite with the main assembly, aim the antenna at the radiating target, and adjust the elevation and azimuth of the antenna to the angles obtained by theodolite. Orient azimuth to true north. The main assembly is only one unit of the rawin set. The other important unit is the control recorder.

3-5. Elevation and azimuth signals pass to the control recorder from the main assembly. The control recorder uses this data to compute altitude. Readouts and printed record of altitude, elevation, azimuth and elapsed sounding time are provided at the control recorder. Remote control of the main assembly also is possible from the control recorder. Figure 10 gives you a visual idea of the control recorder. The printout gives valuable data for the computation of winds. Elapsed time shown on the printout can be switched to either 1, 2, or 10 prints per minute for automatic recording. A manual printout can be obtained as well. A second unit of the ground equipment presents a printout of the meteorological data.

3-6. **Radiosonde Recorder.** The purpose of the TMQ-5 recorder is to provide a graphic record of the transmitted meteorological signals. On this graphic record begins the operator task of selecting significant levels and evaluating data; but that is discussed in a later section of this chapter. The TMQ-5 performs one necessary step toward the evaluation of the sounding. It converts audiofrequency signals to direct current (dc) voltages. The strength of the dc voltage is proportional to the audiofrequency that creates it. The dc voltage excites a pen-positioning system, causing the pen to scribe the signals upon graph paper. A rawinsonde operator evaluates the sounding data as the graphed recording (called *recorder record*)

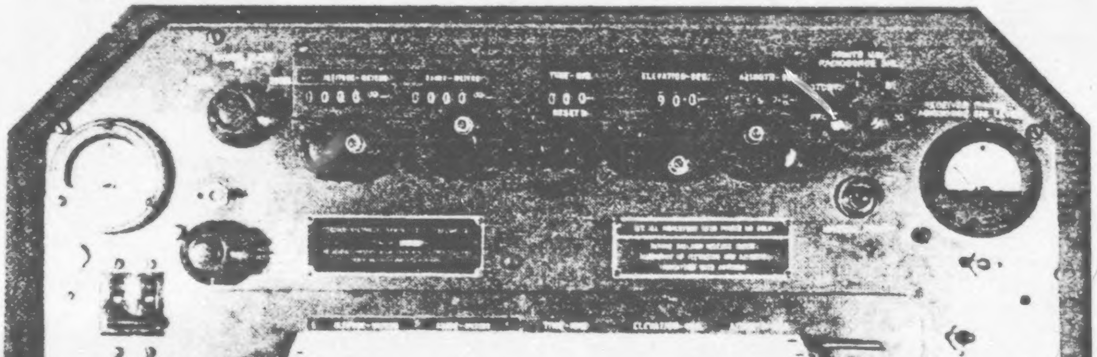

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Figure 10. Control recorder.

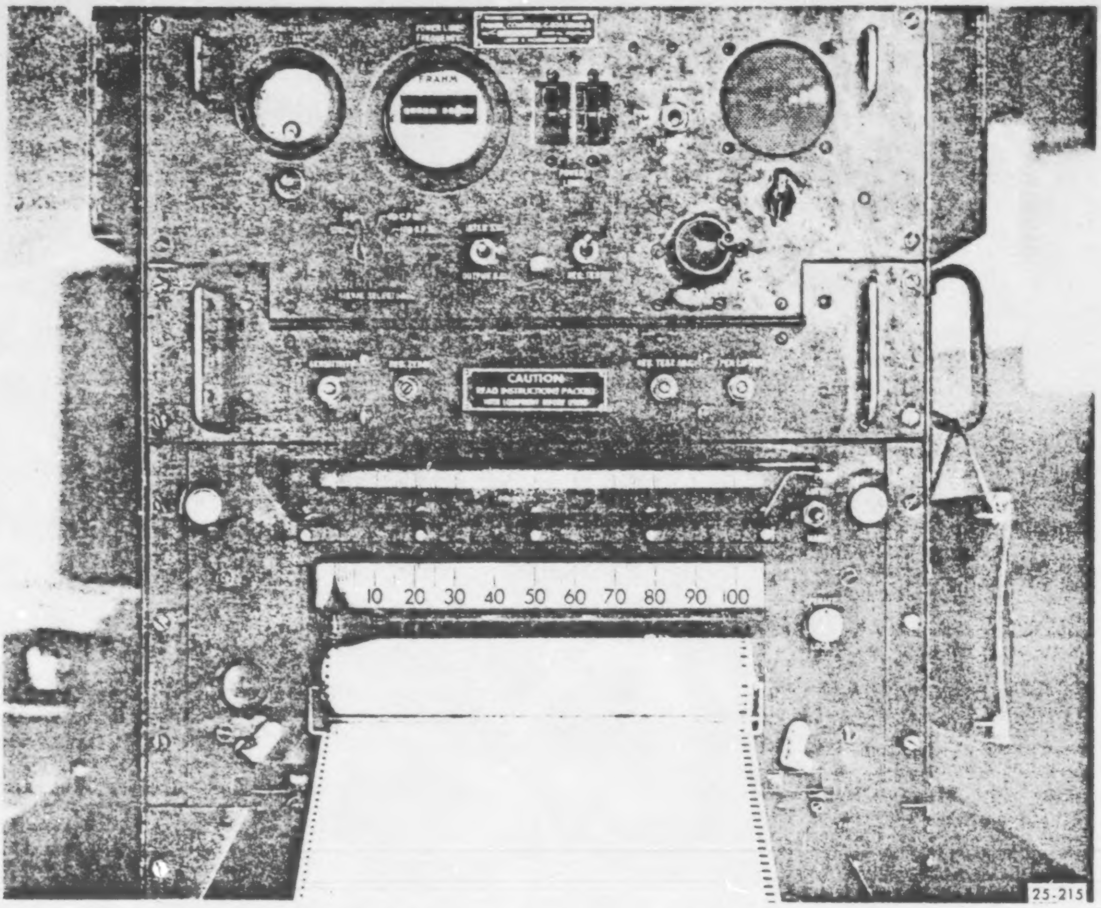


Figure 11. Radiosonde recorder.

feeds out from the TMQ–5, figure 11. Notice the numbered scale and pointer located above the paper roll in the illustration. The scale matches the printed lines on the paper. These lines are called *ordinates*. To divide the recorder into time divisions, horizontal lines spaced ½ inch apart extend across the page. Normally, the paper feeds from the TMQ–5 at ½ inch per minute.

3-7. These lines provides the TMQ–5 operator with a reference frame when evaluating the sounding data. As you choose significant points within the sounding, the chosen points can be time-referenced. Temperature and humidity data can also be compared according to ordinate value. In a later paragraph, we discuss level selection and data evaluation in more detail. Assigning ordinate values to temperature and humidity data is not directly meaningful until two bits of information become known. You must know the *actual* temperature and humidity value of any single ordinate. Knowing that, you can compute both measures for any other ordinate. As an example, if 70 ordinates equals 24° C., then you may, by simple computations, arrive at the temperature for any other ordinate. Finding this known relationship is the purpose of the baseline check. We discuss baseline evaluation in a later paragraph also, but the baseline check set is the next topic of this section.

3-8. **Radiosonde Baseline Check Set.** During preflight preparation of the radiosonde, the baseline check sets up the known relationship between ordinate and temperature or humidity that exists for the entire sounding that follows. You must be careful to find the correct equality. Imagine the difficulty in equating an ordinate value under conditions of rapidly changing temperature or humidity. Each change in temperature would result in a new ordinate value and you could have very little confidence in the accuracy of each value. Best results are obtained by stabilizing the temperature and finding the ordinate that equals a single temperature.

3-9. The GMM–3 baseline check set provides an environmental chamber, figure 12, in which you may secure known and stable conditions of temperature and humidity. Place the radiosonde in the check set chamber. With the door closed, the only effects upon the radiosonde are those within the chamber. Temperature within the chamber is indicated on a psychrometer which you can see through a window. Psychrometric readings also provide relative humidity, as you know. Once the radiosonde is installed in the chamber, you can automatically switch the sensors to measure the temperature and humidity within the chamber. The measured conditions are transmitted by the check set to the TMQ–5 recorder. On the recorder record, you can see the results of the check set measurements. When the check set environment settles down to stable conditions, you simply observe the psychrometer readings and set them equal to the recorded ordinates. To make certain that no electrical error has affected the signal, reference signals are transmitted within the sequence of temperature and humidity measurements.

3-10. The first step in obtaining an accurate upper air sounding is to make a valid baseline check. If you cannot rely on the baseline ordinate-temperature relationship, then all other ordinate-temperature relationships obtained during the sounding are unreliable as well. After satisfying the baseline requirements, the sonde is ready for flight train assembly and preflight procedures. Now we shall begin a discussion of the flight equipment—the sonde, its components, and related flight equipment.

4. Flight Equipment

4-1. Compared to the ground equipment, the flight units are relatively simple in design and purpose. However, they must be sturdily built to withstand the winds at upper levels, but with a sensitivity that is able to detect small changes in temperature, humidity, and pressure over a wide range. For example, the temperature sensor must be sensitive to 1° C. changes within a possible range from +25° or 30° C. at surface to −60° C. or lower in the stratosphere. Similar strenuous demands are placed upon the pressure and humidity sensors. The following para-

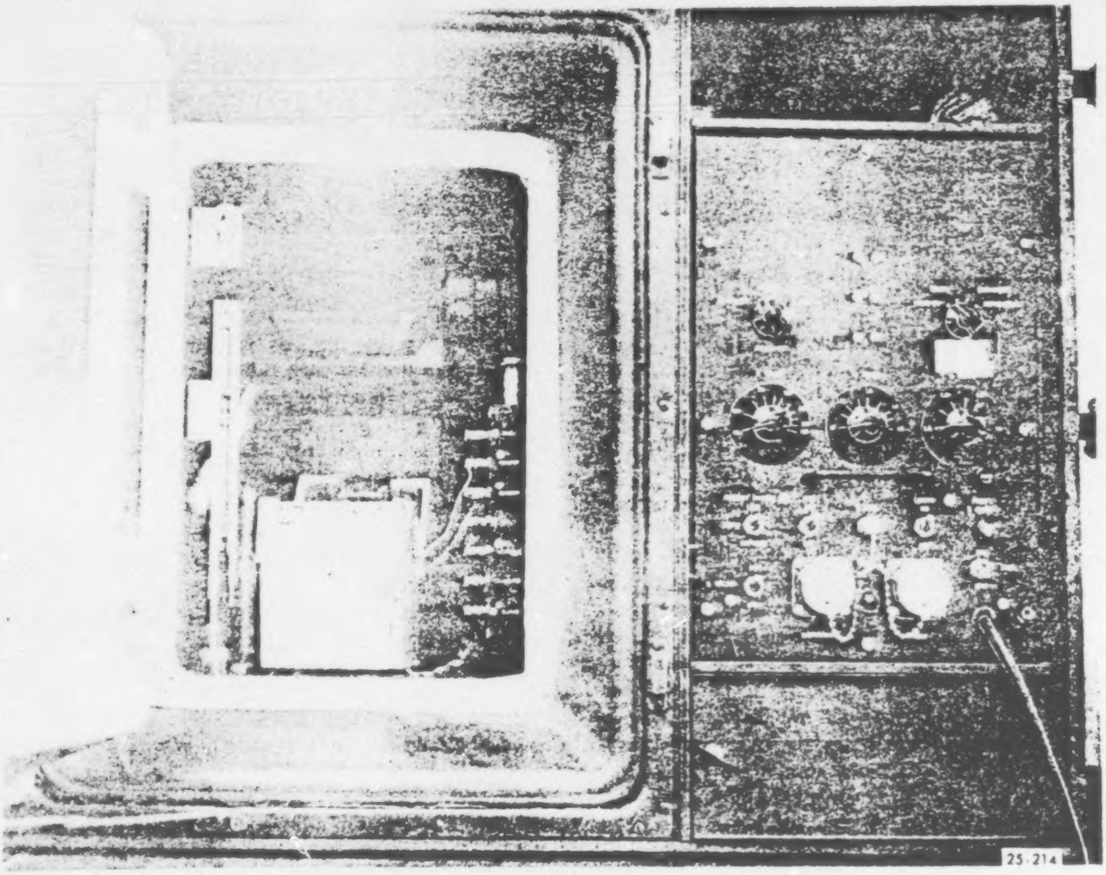
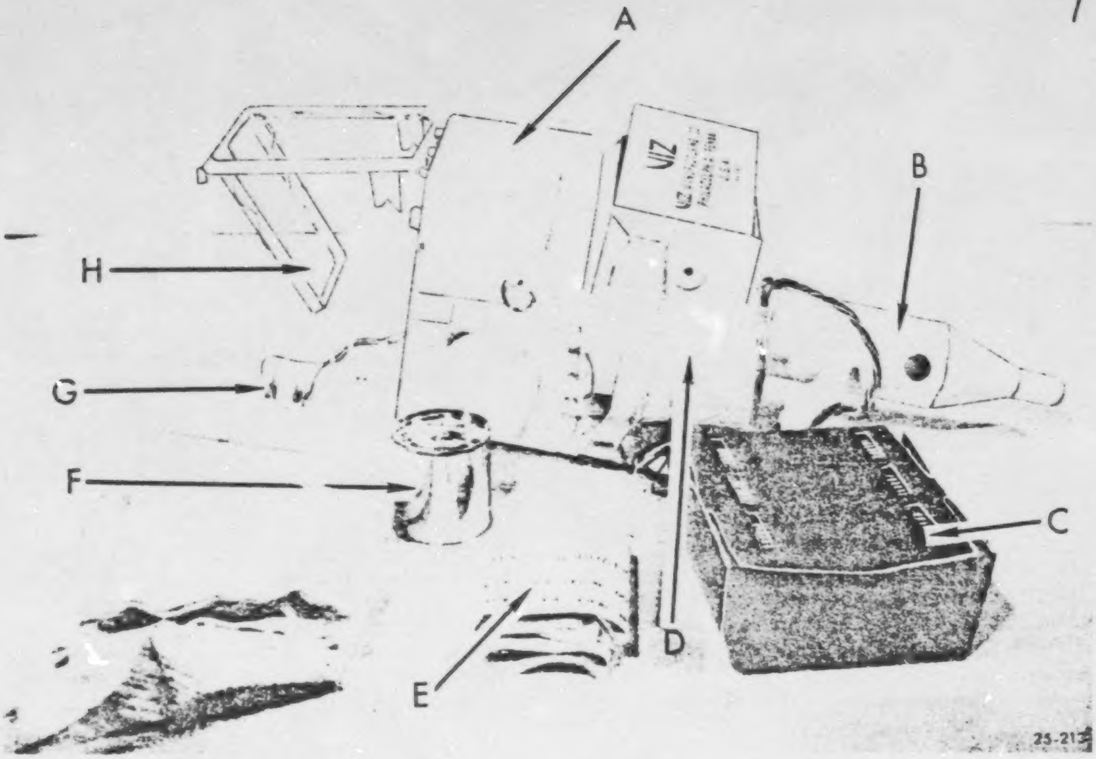


Figure 12. Baseline check chamber.



A. Modulator
B. Transmitter
C. Battery
D. Hypsometer
E. Calibration chart
F. Hygristor (in can)
G. Hygristor location
H. Thermistor

Figure 13. Flight equipment.

graphs enable you to explain the basic principles behind the sensing devices in the radiosonde and to describe the flight train.

4-2. **Radiosonde Sets.** This term (radiosonde) describes the completely assembled sounding instrument with battery, transmitter, and sensing devices. A layout of the radiosonde in figure 13 shows the shape and relative size of its several components. The terms "hypsometer," "hygristor," and "thermistor" refer to sensing devices. To begin our discussion, we investigate the features of the battery and transmitter.

4-3. *Battery.* Serving as the power source for the radiosonde transmitter, the wet-cell battery, in figure 13, should be activated according to instructions packed with the battery. Serious errors can occur if the battery does not provide the minimum voltages required. Making a voltage check permits rejection of an underpowered battery. After activating the battery, place it under a load for about 5 minutes. This allows battery voltage to build up. Connecting it to the test set is a good way to load the battery. Reject a battery that does not reach minimum voltages in an established period of time. Once you place the battery under load, release time should be within 25 minutes. This keeps battery drain to a reasonable level. Should you need more than 25 minutes, disconnect the battery. You may leave the battery disconnected for 15 minutes; but longer than that requires you to make another voltage check to again insure minimum voltage requirements. Batteries placed in storage should not be subject to extreme temperatures. Temperature extremes and prolonged storage encourage deterioration of the battery. A strong battery is needed to prevent fading signals during a lengthy sounding.

4-4. *Transmitter.* The transmitter depends upon the battery. A simple locking arrangement attaches the transmitter to the bottom of the sonde. Transmitter frequency is intended to be 1680 MHZ (±2 MHz). An adjusting screw is available for you to bring the frequency within tolerance. No other action should be necessary. Reject transmitters with broken plugs and transmitters that cannot be securely attached.

4-5. *Sensing devices.* Leaving the power and transmitting sources of the sonde, our next topic, sensing devices, can be divided into two classes. First, we investigate the *temperature and humidity* elements. Next, we discuss the *baroswitch*.

4-6. Normally, the temperature element (*thermistor*) is factory-installed on the sonde in the position shown in figure 13. The thermistor is an electrical resistor coated with a white pigment to reflect solar radiation. Thermistors with chipped or soiled coatings may be used for night flights, but broken leads or thermistors must be replaced. They should not be repaired. Another type of electrical resistor *(hygristor)* acts as a humidity element. Hygristors come packed in an airtight can (shown in fig. 13) to avoid exposure to handling and humidity before using. When you open the can, inspect the humidity before using, and be sure to inspect the humidity indicator if one is packed, to check its color. A blue-colored indicator shows a usable hygristor. Reject the hygristor if the paper indicator color is pink or white. Open the container to install the hygristor just prior to making a baseline. *Avoid touching the film portion* of the hygristor, taking care to handle only the metal edges while installing the element. *Reject* a hygristor whose film has been touched. Two clips hold the element in place within the sonde. Sometimes you may find it necessary to bend the clips together slightly to hold the hygristor more securely.

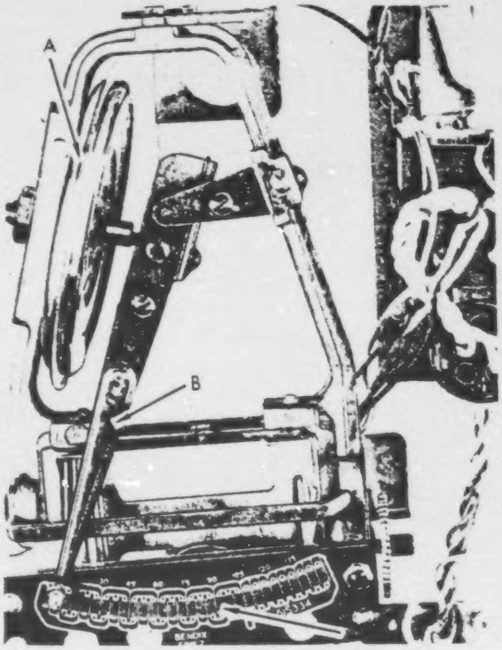
4-7. Presure sensing devices used in the radiosonde are called the *baroswitch* and *hypsometer*. They are not alike—each device has a different purpose. Figure 14 illustrates that the baroswitch can be separated into three parts. Sylphon cell (A) is an aneroid device that reacts to the pressure changes. The reaction then passes through the linkage and contact arm (B) and causes movement across the commutator bar (C). The commutator actually causes the switching between temperature and humidity sensing devices so that either one or the other is transmitted at any time.

4-8. A hypsometer measures pressure by employing a relationship between the temperature of an ebullient fluid (Freon 11) and atmospheric pressure. A small thermistor bead measures the Freon 11 temperature. The hypsometer comes installed with the sonde as shown in figure 13. At lower altitudes, the baroswitch measures pressure. Above altitudes corresponding to about 100 mbs, pressure measuring is by hypsometer because it achieves greater accuracy. Thus, a radiosonde equipped with both baroswitch and hypsometer employs one device up to 100 mbs and switches to the other device above 100 mbs. Sondes not equipped with the hypsometer rely on the baroswitch to measure pressure during the entire sounding. Remaining flight equipment is separate from the sonde, though attached by cord, and is described as *flight train*.

4-9. **Flight Train.** This portion of the launched equipment does not vary significantly from sounding to sounding. Even the method of assembly is hardly different. Normally, white nylon cord ties the flight equipment together. Heavy, waxed cord is equally good. Minimum length of the train is 70 feet and more than 120 feet is unnecessary. A waxed-paper parachute is tied in the flight train to slow the descent of the radiosonde after the balloon bursts. Though the sonde is not heavy, falling from altitudes of 100,000 feet allows it to gain some speed. The parachute does not cause the sonde to float lazily to earth, but does reduce the amount of damage that the falling sonde might inflict.

4-10. When a release must be made in high surface winds, a train regulator permits the gradual payout of cord so that the sonde is not jerked aloft at release. Approximately 60 feet of twine is wound on a reel and a braking mechanism regulates the unwinding. The regulator takes the place of most of the normal flight train length. The last item of flight equipment to discuss is the lifting part—the rawinsonde balloon.

4-11. Rawinsonde balloons are spherically shaped, thin-walled films of natural or synthetic rubber (neoprene). "Thin-walled" means a



A. Sylphon cell
B. Contact arm
C. Commutator bar

Figure 14. Baroswitch.

thickness of from .002 to .004 (thousandths) of an inch when inflated for release. Naturally, as balloon expansion takes place aloft, the film becomes even thinner—perhaps as thin as .0001 (ten-thousandths) of an inch. In more graphic terms, the balloon at release is thinner than a piece of ordinary writing paper. At its thinnest, just before bursting, it would take 100 balloon thicknesses to equal a punch-card. The growth in size is equally impressive. From a release diameter of 6 feet, the balloon blooms to about 24 to 32 feet at bursting. These statistics help you realize the need for careful handling of the balloon during preflight steps. The smallest cut or scratch in the balloon surface caused by a ring, watch, sharp fingernail or other object, could result in premature bursting. Any handling should be by the balloon neck (that part which is thicker and tougher), where the inflation takes place. In fact, the balloon is attached to the flight train at the neck, which indicates the strength of that portion of the balloon. Either helium or hydrogen gas provides the lift.

4-12. All of the equipment mentioned in this section, when put together, makes up the flight train. There are certain steps to follow in assembly, but we will consider only the fundamental assembly and the relative position of each item. At the train's top or beginning is the balloon. After inflation, the neck is tied off, folded upward once, and tied off again with a single piece of doubled cord. One end of the doubled cord provides an attachment for the parachute, which you must tie not more than 5 feet below the balloon. Tie the free end of the parachute to the upper eye of the regulator (if a regulator is needed). A ring on top of the radiosonde is attached to the free end of the train regulator cord. Without a regulator in the train, tie about 70 feet of cord between the free end of the parachute and the radiosonde ring.

4-13. The ground and flight equipment discussed in this section are always undergoing improvements. Electrical transmitting, receiving, and measuring equipment is especially vulnerable to change because of the rapid strides in that field. The equipment in this section represents the current status of rawinsonde sounding. Before the actual sounding can be made, some important preflight checks and tasks must be done.

5. Preflight Procedures

5-1. Under the title "preflight procedures," three preparational functions are included. The sonde must be inspected, prepared for flight, and checked. Meanwhile, the balloon needs inflating. Finally, the release and its notations are included. Some steps must be taken in order. Generally, this section attempts to keep the proper order of events when it is important.

5-2. **Sonde Preparation.** Prior to release, inspect and check the sonde. First, compare the serial numbers of the sonde and the calibration chart to see if they match. Each sonde is equipped with its own calibration chart, as shown in the upper portion of figure 15. A calibration chart provides a printed record of the pressure corresponding to each segment on the commutator bar. The only way you can compute pressure for the sounding is by counting segments on the commutator bar and finding the pressure from the calibration chart. All calibration charts are not identical; thus you must check serial numbers to insure the proper match between baroswitch and calibration. Reject the sonde if serial numbers disagree. Hypsometer sondes must also have a hypsometer calibration chart, figure 15 lower. Serial number agreement here is also mandatory.

5-3. Having convinced yourself of matching calibration charts, begin a visual inspection of the sonde. Examine the installed thermistor, checking for breaks or loosened solder joints. Next, inspect the hygristor clips for oxidation or looseness. Your check of the baroswitch section includes the linkage and contact arm to see that contact is made on the commutator. The commutator must be free of dirt and corrosion. A plastic-covered relay mounted near the baroswitch should be checked to see if it remains covered. Make no attempt to clean or adjust the relay. Continue your inspection to the transmitter and hypsometer units. Search for breaks or visible damage.

5-4. Next, after visual inspection, put the sonde through a series of electrical tests. Actually, the sonde should have been tested when it was received. Otherwise, it must be tested before flight. During testing, another source of power besides the battery should be used. The first test is the radiofrequency check which tests the transmitter. Next is a series of tests which check the sonde's response to certain reference voltages and voltage stability. Then you follow with electrical tests upon the thermistor, hypsometer, humidity circuit, and relay. During the hypsometer test, no fluid need be present in the hypsometer. Similarly, you can make a valid test of the humidity circuit without installing the hygristor. If at any point during the tests the sonde fails to meet minimum standards as outlined in FMH-3, *Radiosonde Observations*, reject the sonde. An acceptable sonde may then be prepared for sounding.

5-5. The next step in preparing the sonde is to activate the battery. Check it too. Install the hygristor in the clips. Again, some electrical tests

CONTACTS	PRESSURE (mbs)
011	0917
010	0933
009	0946
008	0961
007	0974
006	0988
005	1006
004	1020
003	1034
002	1048
001	1063
000	1088

25–209

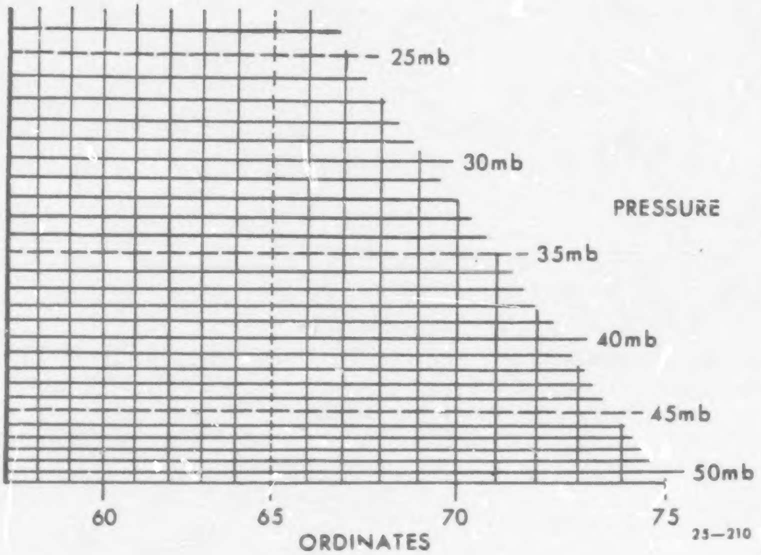


Figure 15. Calibration charts, pressure (upper), hypsometer (lower).

are made with the sonde, but these tests become part of the sounding record. The tests are recorded on the TMQ–5 and are included with the actual sounding. Satisfactory completion of these tests leads to the next important step—*baseline*.

5-6. *Baseline* is not strictly a part of sonde preparation. Basically, the sonde is prepared for the purpose of making a valid baseline. Though the sonde is not yet airborne, baseline becomes an integral part of the sounding. An earlier paragraph mentioned the purpose of baseline checks. All tests and checks prior to baseline were aimed at validating the physical properties of the sonde, its circuitry and sensors. Baseline check aims at establishing measurable relationships between temperature, humidity, and electrical signal. In figure 16, a typical baseline recording is illustrated. While the sonde is in the baseline check set environmental chamber, the sensors are alternately switched into the transmitting circuit. The sequence of signals during baseline is generally as follows: temperature, reference, humidity, reference. This cycle is repeated as often as needed to obtain a valid baseline. Reference signals (at the 95.0 ordinate) measure the electrical voltage and have nothing to do with temperature or humidity measures. Reference is vital to show whether or not the signals you are receiving from the sensors are properly alined with the recorder paper.

5-7. After receiving two cycles of baseline signals, evaluate for a valid baseline. A valid baseline must satisfy the following requirements.

a. Two consecutive temperature traces (signals aligned so that a line connecting the upper end is parallel to the ordinates of the record).

b. Two consecutive humidity traces alined in similar fashion as temperature; or three traces alined in a trend, either rising or falling. Even the trend should not vary by more than 0.3 ordinate between highest and lowest point.

c. All reference traces must record at 95.0 without adjustment of the controls. When evaluating a trace (signal), pay no attention to the short tail at the top of the trace. This represents pen drag as it moves on to the next trace, and does not measure anything.

5-8. When you recognize a valid baseline, draw a line across the paper at the top of the last humidity trace. This is illustrated in figure 16. Draw lines connecting each set of traces to intersect the drawn baseline. Immediately to the right-hand side of the termperature line, enter the ordinate values of both temperature (above line) and humidity (below line) traces. These ordinate values are set equal to the conditions within the check set chamber. During the sounding, manual computers convert ordinate values of the recorded traces into meaningful temperature and humidity measures. To use this convenience, lock the baseline data into the computers.

5-9. One step remains to be done to the sonde before you send it aloft. Baseline established known values for temperature and humidity sensors, but nothing has been established for the pressure. You need to set the baroswitch at a position on the commutator bar that equals your current station pressure. This procedure is called *pressure-contact setting.* First, read the station aneroid. Refer to the calibration chart to obtain the commutator contact that equals your station pressure. Adjustment of a baroswitch detent screw permits you match contact segment with station pressure to 0.1 mb. Pressure-contact setting finishes your adjusting and checking of the sonde. If the hypsometer sonde is being used, fill the hypsometer flask with the fluid. The sonde is now ready for release; however, a difference of 30° C. (54° F.) between indoor and outdoor temperatures places a need for exposing the sonde before release. Exposure to the outside temperature permits the sensing elements to adjust to conditions. Allow the exposure to take place in a sheltered but unheated place. While sonde preparation takes place, another operator should condition and inflate the balloon.

5-10. **Balloon Inflation.** It was pointed out earlier that you must handle balloons with care. Careful handling begins with storage. Store the balloons away from temperature extremes (less than 32° or above 110° F.) and removed from large electric motors or generators. Motors and generators emit ozone, which is harmful to neoprene. Avoid touching the balloon film with bare hands. Because lengthy periods of storage cause neoprene balloons to lose some elasticity, balloons stored over 1 year must be conditioned. Conditioning helps avoid premature bursting.

5-11. Three methods of balloon conditioning are available. Electric conditioning uses a bal-

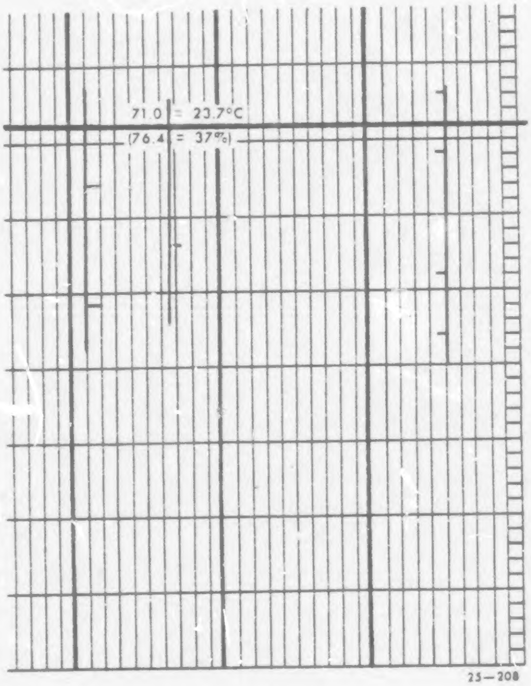


Figure 16. Baseline check.

loon conditioner. This is a box where uniform conditions of warm, moist air restore the balloon's elasticity. Another method is to immerse the balloon (but not the neck) in a smooth tray of hot water for a short time (at least 5 minutes) and allowing the water to drain when immersion is over. If neither of these methods is available, hold the balloon over a heater or radiator. Avoid direct heat contact but strive for uniform heat conditioning. Inflate the balloon as soon as possible after conditioning.

5-12. Either helium or hydrogen gas provides the lift. Hydrogen, being inflammable and explosive, requires extreme caution if you value your skin. *No smoking during inflation is allowed!* Avoid rubbing against the balloon with your clothing at any time. The balloon could accumulate a static electrical charge that might prove explosive. Even rapid inflation could generate a dangerous level of static electricity. Inflate the balloon *slowly* regardless of the gas used. Briefly, inflation is as follows.

5-13. Tie the balloon neck to the inflation nozzle. Place the desired amount of inflation weights on the nozzle. Inflation weights are used to control the amount of lift the balloon will have. A known amount of lift thus permits you to know the rate of balloon ascension. Affix the weights and begin inflation, slowly, till the balloon appears about half-filled. Stop inflation and listen for leaks. Reject the leaker. If no leak is detected, proceed to full inflation, that is, until the balloon lifts the nozzle and weights. Tie the neck with the doubled cord mentioned in the section on flight train. Now all parts of the flight train are ready for assembly (already discussed) and eventual release.

5-14. **Balloon Release.** Release terminates the preflight procedures, but also begins the observing and evaluation portion of the sounding. Even though a few hours of complicated evaluation and plotting lie ahead, a smooth and successful release inspires an inward sigh of relief. You have checked, tested, and protected the sonde during preflight to arrive at this point. All your efforts can be nullified in just 5 or 10 seconds of sloppy release methods. Frustration is watching the sonde lift out of your reach with its temperature sensor broken and dangling worthlessly! To prevent this happening, plan the release to account for wind and obstructions near the release area. This means choosing the actual point of release to permit the sonde ample clearance around or above wires, towers, buildings, or trees toward which the wind would aim the sonde. Another point to consider is that the man with the balloon has a more difficult job in controlling and handling than the man with the sonde. Thus, it is better for the balloon handler to walk less distance from the inflation shelter than his partner. The faster the wind, the more awkward becomes the balloon. It is practically impossible to hold a balloon steady in a gentle or moderate breeze. Make no attempt to release alone if another man is available.

5-15. Part of your release procedure plan should be to obtain a release clearance. Proper clearance avoids flight conflict between your balloon and air traffic. Coordinate with the control tower or designated authority to obtain the release. Once the balloon is taken out of the shelter, the release should proceed smoothly and rapidly, with no delay. The first observer places the radiosonde top-side-up in his left hand, grasps the cord with his right hand 2 feet above the top of the radiosonde, and extends the train until a slight tension is exerted on his right hand to prevent the train from becoming tangled. The second observer removes the ballon from the shelter. The first observer should position himself downwind from the balloon so that it will pass directly overhead when released. The second observer releases the balloon, and the instant the train slackens, the first observer runs downwind until the balloon takes up the slack. As this happens, he raises the radiosonde with his left hand and brings the cord forward with his right hand. If the movements of his hands are coordinated, the radiosonde will follow the balloon with no noticeable jerk. Though it is not possible to illustrate these motions in a still photo, figure 17 serves to point out some noteworthy features. Notice the padding within the inflation shelter and especially on the doors. Emerging from the shelter with the balloon is a critical maneuver. An unexpected gust can slap the balloon against the door before you can react. The door padding may save balloon puncture. Figure 17 also allows us to point out an improper technique. Despite an apparently calm wind (evidenced by a lack of noticeable strain on the balloon), the two observers are too close together to avoid tangling the train on the ground. They should be far enough apart to extend the train. A tangled train or one that becomes snagged on the ground results in an uncoordinated release or even worse—a punctured balloon or broken sensor.

5-16. Release is accompanied by several entries. First, take a surface weather observation as close as possible to the time of release. Enter the observation on the recorder record and also on the adiabatic chart. Record the time of release (to the nearest minute GMT) on the recorder record, calibration chart, and adiabatic chart. An identification stamp provides a place for you to enter station name, ascension number of the observation, radiosonde serial number, and rea-

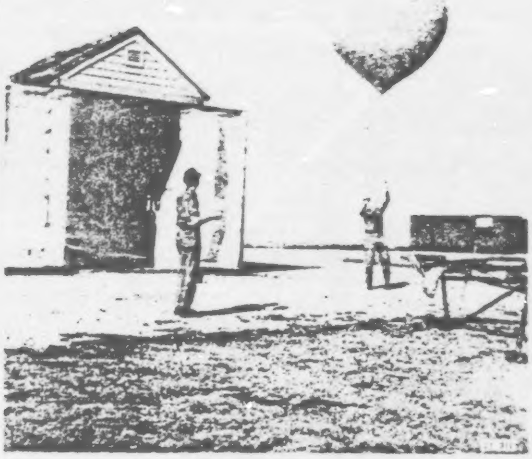


Figure 17. Balloon release.

son for termination within the first 7 inches of the recorder record. A short time before release, allow the recorder to print at the zero ordinate. Exactly at release, turn the recorder to ON and note the time.

5-17. An accurate and timely rawinsonde observation takes three operators working as a team. One man evaluates the recorder record, another plots the adiabatic charts and codes the raob, the third plots winds and codes them. The next three sections outline the duties of these operators.

6. Recorder Record

6-1. As we previously mentioned, the TMQ–5 radiosonde recorder provides a graphic record of the electronic signals sent back by the sonde. Your team of three splits up after release to work each of the three positions. This section deals with the operation and evaluation of data recorded on the TMQ–5. Since the recorder man first evaluates the transmitted data, his evaluation and accurate computations affect the remainder of the observation evaluation. The recorder man has four major responsibilities.

(1) Selecting levels of significance.
(2) Evaluating levels selected.
(3) Recording the data evaluated.
(4) Providing the selected levels to the charts

6-2. [illegible] et these responsibilities, the recorder [illegible] ks with temperature and humidity evaluators which were set up during the baseline check. Setting up means locking in the conversion factor between temperature, humidity, and ordinate that you obtained during baseline. You also must refer to the calibration charts to know where mandatory pressure levels occur in the sounding. A transparent straightedge provides a trending tool between levels. Your understanding of the recorder record evaluation begins with definitions of some common terms.

6-3. *Trace* is the name given to the recorded temperature, humidity, and reference signals. Temperature and reference and some humidity traces appear as inverted Ls. Other humidity traces are long sloping lines. The little tail part of the trace is pen drag upon the paper as the pen moves to the next signal. A *contact* on the recorder record begins at the top of a temperature trace and ends at the top of the next succeeding temperature trace. (See fig. 18.) The base of a reference or humidity trace will normally have the same value as the top of a temperature trace. Contacts are printed on the calibration chart and are used to calculate pressure during the sounding. *Ordinates* are the vertical lines on the recorder graph. The evaluated ordinate for temperature and RH traces is determined and recorded to the nearest tenth. *Reference* is the term for those traces that indicate the recording accuracy of the TMQ–5 recorder. Low references print on the 95th ordinate. They are transmitted for each contact divisible by five between surface and 30 contacts. Between 30 and 125 contacts, they appear for every fifth contact not divisible by 15. High references print on the 97th ordinate. They print every 15 contacts between 30 and 120 contacts. Starting at 130 contacts, they are transmitted every five contacts. *Trending* refers to the straightedge examination of the traces. The purpose of trending is to detect significant changes in the slope of traces for possible placement of levels. Selected levels then are evaluated and considered later for transmission in the radiosonde code.

6-4. The recorder man selects three types of levels: mandatory, significant, and additional. The *mandatory levels* are 1000, 850, 700, 500, 400, 300, 250, 200, 150, 100, 70, 50, 30, 20, 10, 7, 5, 3, 2, and 1 mbs. These selected levels always appear in the code. *Significant levels* mark the boundaries of layers having different temperature lapse rates or vertical humidity slopes. Place the first significant level at release point. Thereafter, significant levels, revealed by trending, are placed randomly. Random selection, perhaps, is not a completely accurate description. A priority has been set for selection.

6-5. Trend and select levels for temperature departure first, additional levels second, and relative humidity levels last. However, when selecting levels for temperature, stay aware of the relative humidity trends so that, when necessary, you may select a level to reflect changes in trend of both temperature and relative humidity. When the levels have been selected and the evaluated data plotted on the adiabatic chart, the resulting curves must closely reflect the profile of the recorded traces. They must agree everywhere with the traces within ±1° C. from the surface up to and including 100 mb and ±2° C. from 99 mb up to and including the termination, and within 10 percent relative humidity for all humidity evaluated.

6-6. *Additional levels* include several significant reasons for selection, one of which is the point of balloon burst. If no balloon burst can be determined, select the highest usable point on the recorder record. Place levels at the beginnings and endings of strata whose temperature is classified as missing or doubtful, and also when humidity is classified as missing. Select another level within each missing data layer. Place a level to mark the base of an icing layer when it occurs.

6-7. Each selected level is then evaluated for temperature, humidity, and pressure contact. This means reading the ordinate value of the temperature trace (or trend) that intersects your chosen level. The same is done for humidity. Pressure contact is determined by counting the number of contacts that have elapsed between release and the chosen level. Enter all of this information at the level chosen and near the temperature trace, as shown in figure 19.

6-8. Evaluate temperature by the left-hand edge of the trace. Read the ordinate value to the nearest tenth. By use of the temperature evaluator, you obtain a corresponding temperature value for the ordinate found above. Evaluate humidity also by the left-hand edge of the trace, and read the values to the nearest tenth of an ordinate. Assign the contact number to the level after you have estimated the proportional part of the contact at which the level occurs. Enter contacts to the nearest tenth. There is no need for you to count all the contacts one by one from the release level. You may begin counting from the last reference trace. They print at every fifth contact and you number them as they appear.

6-9. At each high and low-reference contact, write the contact number (5, 10, 15, 20, etc.) to the right of the reference trace, provided that the contact number is a multiple of 5. Connect each successive recorded low-reference (omitting high references) contact with a straight line, termed the "drift line". Drift occurs on the recorder record when the low or high reference traces do not print on their respective ordinates. Drift may be corrected by a manual adjustment at the TMQ-5. Drift line is an important indicator because, if it shows the reference traces are off, then perhaps the temperature and humidity traces are off as well. Thus, drift line must always be drawn to indicate the accuracy of the electrical signal.

6-10. At the bottom and top of each low-reference contact, and immediately to the left of it, enter to the tenth of an ordinate, the difference between the low-reference trace and the ninety-fifth ordinate. Prefix the correct algebraic sign that would move the trace back to its proper position. If the difference is zero, enter 0. These entries are called "low-reference drift correction." Your objective should be to main-

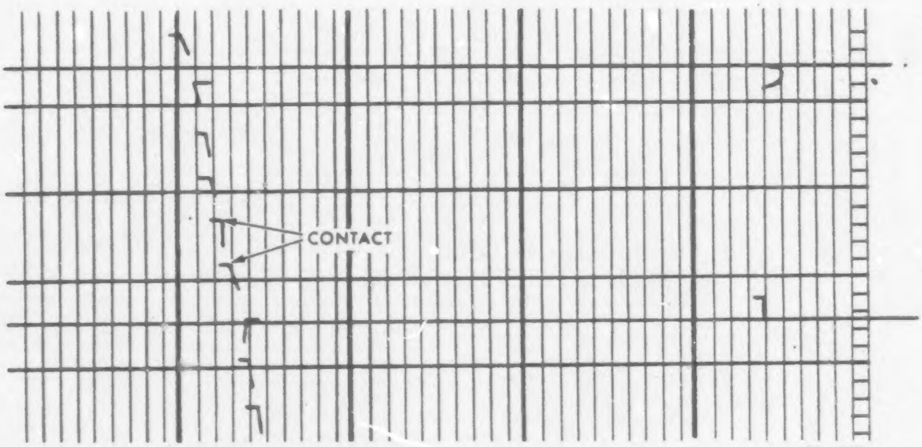


Figure 18. Contact.

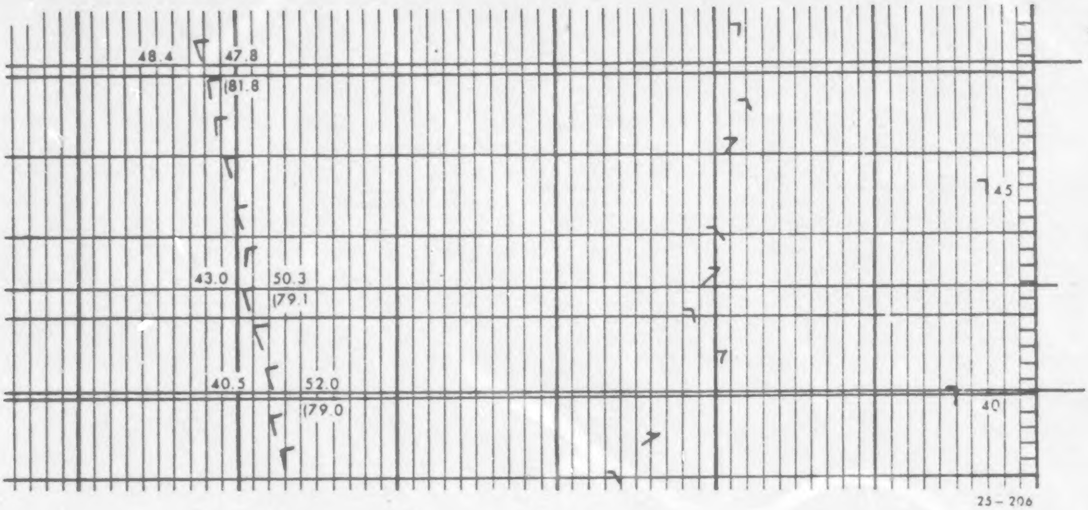


Figure 19. Recorder record.

tain zero drift when possible. Another feature that you need to watch for during a sounding is a *shift* of all elements. A shift is recognized as an abrupt sideways movement of the recorded traces: drift is gradual. Both drift and shift of the traces need to be corrected. Also your evaluation of the traces must take into account the error introduced by drift, shift, or both.

6-11. The levels you select must be evaluated and labelled. Recorder record entries are all made in pencil. Your level data becomes the raw data that the charts man uses to construct the adiabatic charts. On levels selected, enter the elapsed time from release. Starting with the release level (surface), you begin with 00. These time entries are made using the first digit as whole minute(s) and the second digit as tenths of minute(s). Use three digits above 9.0 minutes. Continue to use the baroswitch trace for pressure evaluation until the difference of this pressure value and the hypsometer is 0 mb. If you find no point where the difference is 0 prior to the point where the baroswitch trace indicates 15 mb, use the point of *least* difference if it is 3 mb or less. If the closest point of difference is greater than 3 mb, continue using the baroswitch traces for the remainder of the sounding. When the above conditions are met, use the hypsometer trace to evaluate pressure data for the remainder of the flight except when the hypsometer fails.

6-12. Your evaluation accuracy of temperature, humidity, and contact is critical to the eventual accuracy of the code. The temperature, humidity ordinates, and pressure contacts that you give to the charts man provide him the raw data for converting to actual temperature, humidity, and pressure measures. Our next section looks into the duties of the charts man as we follow the raw sounding data to its second step in processing.

7. Plotting The WPC 9–31

7-1. The recorder man selects significant features that occur during the sounding and evaluates those points through the use of significant and additional levels. The charts man transfers these significant features to the adiabatic charts by constructing the points into plotted curves. The charts plotter has the following tools to achieve this task: a series of three adiabatic charts—DOD–WPC 9–31 (A, B, and C), a temperature evaluator, humidity evaluator, calibration charts, and a psychrometric computer.

7-2. The first step in charts plotting is to enter the data (called out by the recorder operator) into a data block provided on the chart. Space is allowed in the data block to enter the converted raw data. Use the calibration chart to convert contacts into pressures. Convert temperature and humidity ordinates with the evaluators mentioned above.

7-3. Before discussing the plotting of the converted data, a brief discussion of the adiabatic charts would be helpful to you. The adiabatic chart series provides a vertical pressure profile in three steps. Chart A (WPC–9–31A) covers the range from surface to 400 mbs. Chart B, allowing for overlap, covers from 500 mbs to 100 mbs. Chart C, also overlapping, takes the sounding from 125 mbs to 1 mb. Each chart has a temperature scale alined horizontally, a smaller humidity scale near one edge of the chart and, finally, a height scale graduated alongside the temperature scale. Though the chart seems crowded, the scales are expertly placed so that three curves may be plotted without conflicting with each other.

7-4. Begin plotting by drawing the first level entered in the data block at the proper pressure. Upon the level, plot the converted temperature and humidity measures. Continue plotting levels and connecting plotted points so that two vertical profiles begin to develop. One profile represents the temperature of the sounding and the other, humidity. With these two profiles started, you may begin the third curve. It is called the *pressure altitude* (PA) curve. The PA curve construction relies upon two facts. First, the PA curve begins at surface elevation, a fact which you can easily obtain. Further, PA construction depends upon computing a thickness value (in meters) between pressure levels. Thickness is based on knowing the temperature and humidity between the desired levels. Since the temperature and humidity profiles are started first, you may easily compute the thicknesses right from the chart itself. It is the PA curve which is vital to winds plotting. That task is discussed in the next section. The final responsibility of the charts man involves encoding the data for transmission.

7-5. Volume 3 contains a complete breakdown of Radiosonde Code. There is no need to repeat that discussion. Instead, the selection of levels to be transmitted from the plotted adiabatic chart needs to be considered. The mandatory levels provide a good profile of the sounding, but they do not guarantee the reporting of all significant features observed. Significant levels fill in between the mandatory ones. Some reasons for selecting significant levels are in the list below.

- Surface
- Bases of clouds and icing.
- Highest and lowest temperature on plotted curve.
- Highest and lowest humidity on plotted curve.
- Bounding levels of missing or doubtful temperature.
- Bounding levels of missing humidity.
- Termination.

Upon selecting the levels listed above, one more rule for level selection should be considered. A sufficient number of levels should be included so that a linear trend between any two *significant* levels already selected (for reasons above) gives a close approximation to the observed data. The term "close approximation" is defined in two ways. For the portion of the sounding below the 300 mb level, close approximation means 1° C. Thus, a trend between any two significant levels chosen for transmission should fit the plotted curve within 1° C. Above the 300 mb level, close approximation means 2° C. A trending rule applies to the plotted humidity curve as well. "Close approximation" to the humidity curve means within 10 percent. Uusally, after all the levels are selected for the other reasons, the humidity curve is already closely fitted and trending for humidity adds no further levels.

7-6. These selected levels, mandatory and significant, are coded in the radiosonde form. The coded levels are placed into message form—Parts A, B, C, D and first or second transmission. Where you encode the level depends upon the type of level and its position in the sounding. The reason for two transmissions is to avoid delaying the data in order to finish evaluating and encoding the entire sounding. The 100 mb level has been selected as the dividing point between transmissions. It is felt that if the radiosonde data up to 100 mb can be transmitted as soon as possible, a vital part of upper air data is available to users. The first transmission also contains tropopause information, a level (or levels) which is selected separately from the others and coded separately at the end of Part A, Radiosonde Code.

7-7. It is considered important for data to reach the users as quickly as possible after observation. This is true in all phases of weather observing. Some weather data is considered perishable; that is, the older it becomes, the less useful it is. For this reason, certain information obtained by sounding is made available even before the first transmission. *Early transmission messages* contain this early data.

7-8. Code, for early transmission, the following information: the usual data for the 850, 700, and 500 mb pressure levels and the stability index. Stability index is a measure of the tendency of the atmosphere to rise (as in convection) or settle (as in subsidence). Early data transmissions are useful to the meteorological and forecast centers in preparing their products. This gives the data an important role and explains why it is needed early. The charts man, then, fills a central role in the rawinsonde team. He turns the raw recorded data into actual meteorological measures. From plotted curves, he brings together the coded data for transmission. One of his plotted curves, the PA, is vital to the computation of winds.

8. Winds Aloft

8-1. In this short section, the task of plotting winds is considered. The winds plotter relies on the PA curve from the charts plotter. However, the charts plotter relies upon the coded winds from his partner to complete the rawinsonde code mandatory levels. Undeniably, the rawinsonde team truly relies upon teamwork. This chapter's last section is brief because the details of plotting winds upon the A-1 plotting set, computing HDOs, and measuring speed and direction have all been discussed in the pibal section of this volume. Consequently, only a brief overview of the tasks through the plotting of winds upon the ML-514 plotting board is given here. Main emphasis is upon the selection of levels for encoding and the construction of the upper winds code.

8-2. Winds-aloft observations are evaluated by projecting the path of the balloon onto a plotting board and measuring the displacement over a given interval of time. Wind directions and speeds are computed for specified time intervals and plotted against altitude on a graphing board to provide a vertical profile of the wind movement around the station. The observed elevation and azimuth angles are recorded by the plotter. His task is to convert these angles into a minute-by-minute picture of the direction the balloon took and the horizontal distance out (HDO) it travelled from the release site. From this plotted picture, and using scales specially constructed, he may derive windspeed and direction for each minute. All of this is done on the A-1 plotting set. Then he plots the speeds and directions on an ML-514 graphing board to construct continuous curves from surface to termination. Windspeed and direction can easily be extracted from the graphed curves for any height interval desired.

8-3. The final step in preparing the wind data for teletype transmission is encoding. The code provides a standard format used by all rawinsonde stations. In coding wind data for upper winds code, you must remember two things. First, there are certain mandatory (fixed) levels that have to be sent out on all observations. Second, there are significant levels of wind data that must be evaluated and transmitted. Also, the mandatory pressure levels of radiosonde code contain wind data if it is available in the sounding.

8-4. Obtaining the fixed level data is a simple task. Aline the movable scale on the ML-514 at the required altitude and read the speed and direction from the plotted curves. No conversion of values is necessary—just read and enter. Upper wind code, like radiosonde code, is separated into two transmissions. Fixed levels of upper wind code are listed below by transmission.

(a) *First transmission (Rawin)*

1000 feet	12,000 feet
2000 feet	14,000 feet
3000 feet	16,000 feet
4000 feet	20,000 feet
6000 feet	25,000 feet
7000 feet	30,000 feet
8000 feet	35,000 feet
9000 feet	50,000 feet

(b) *Second transmission (Rawin)*

70,000 feet
90,000 feet
100,000 feet
110,000 feet
140,0000 feet

and for every 10,000 feet level upward.

8-5. Significant levels chosen for transmission in upper winds code fulfill the same purpose as significant levels in radiosonde code. The definition of a significant level is: A level at which an abrupt change in speed and or direction occurs. Consider 10 knots as an abrupt change in speed and 10° as an abrupt change in direction. Additional significant levels are the surface wind level and the highest level attained for wind data representing the first and last significant levels.

8-6. First code the fixed levels. Then start trending between the fixed levels looking for the 10 knot and/or 10° deviations. When you find a deviation, select the nearest 1000-foot altitude and code it as a significant level. There are two other possible wind levels that you may choose. One is the maximum wind group; the other is tropopause level wind. Maximum wind groups appear in both radiosonde and upper wind codes. To qualify as a maximum wind, the speed must exceed 60 knots. If no such speeds exist during the sounding, report no lesser speed. When a tropopause has been recognized and reported in the radiosonde code, you must supply the windspeed and direction at that altitude for inclusion in radiosonde code.

8-7. Radiosonde code is an extremely vital product. The team taking the sounding must work quickly and in harmony. The transmission schedule for the first portion of the code allows no wasted time after the sounding terminates. Since the recorder operator is first to finish, he aids the man who stands in need the most. The winds plotter waits upon the PA curve from the charts plotter. Thus, if the completion of the PA is lagging, the extra help might best be used at that point. Each man keeps the objective in mind and works toward it—the on-time transmission of the radiosonde code, Parts A and B.

8-8. Refer now to the review exercises for Chapter 2 in your Workbook before going on to the next chapter.

CHAPTER 3

Rocketsonde and Dropsonde Observations

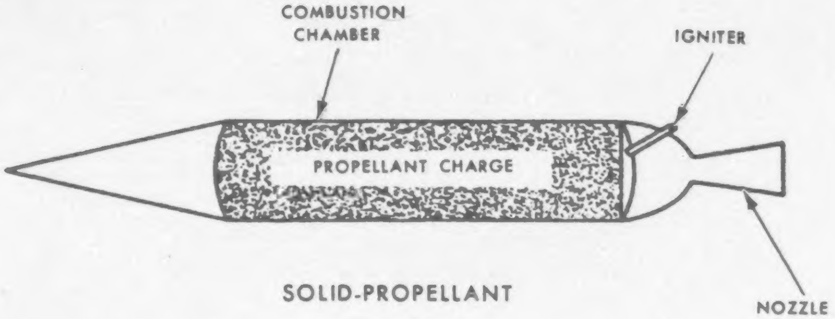
IN ROCKETSONDE operations, instrument packages and sensors are boosted into the upper atmosphere by small solid-propellant rockets. Data are gathered by surface-based instrumentation as the payload descends. Dropsonde instruments, somewhat similar to the type used in rawinsonde, are ejected from specially equipped aircraft, and data are recorded from the descending payload by airborne instruments. Rocketsonde and dropsonde observations fulfill vital Air Force requirements for meteorological data above rawinsonde altitudes or in areas where upper air data would otherwise be unattainable.

2. Weather observers, preferably those with rawinsonde training and experience, are thoroughly screened prior to selection for duty in these highly specialized observing functions. Your technical proficiency, initiative, dependability, judgement, and team spirit are factors that are carefully considered. Since only a small number of observers (less than 200) are normally employed in these subspecialities, no formal Air Training Command (ATC) courses are provided. Selectees for rocketsonde duty must complete a 5-week Rocketsonde Indoctrination Course (Air Weather Service Regulation 50–1) which is conducted at Vandenberg AFB, California. Extensive On-The-Job Training (OJT) is also required before you can be certified and allowed to work without the direct supervision of a qualified rocketsonde operator. Safety is continually stressed throughout the training phases as well as during actual operations. After the Rocketsonde Indoctrination course, before becoming an Airborne Weather Observer, you must complete approximately 2 weeks of ground training and 4 weeks of airborne training. This training is conducted by the Weather Reconnaissance Squadron to which you are assigned.

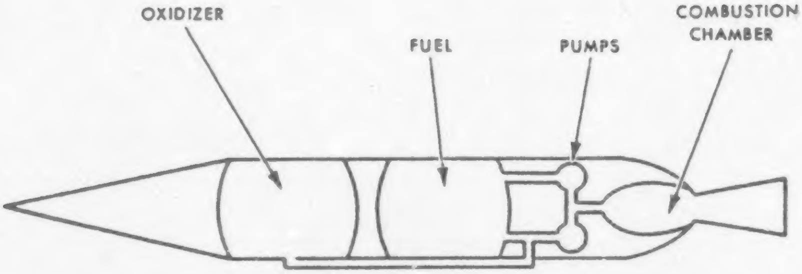
3. This chapter provides background, basic facts, and principles relating to rocketsonde and dropsonde observations. It gives illustrations; descriptions and examples of various equipment; identifies observing methods; and identifies basic procedures for taking, recording, and disseminating the observations. As you study this chapter, you will note many parallels and relationships to rawinsonde observing. Thus, your knowledge of rawinsonde, gained through formal training, from experience, or from this volume, will be most beneficial in your study of this material.

9. Rocketsonde Observations

9-1. Dr. Robet H. Goddard, a Clark University physicist, conducted extensive research in rocketry between 1914 and 1941 and successfully tested the world's first liquid-fuel rocket in 1926. His proposal to use sounding rockets to probe the atmosphere was not seriously considered by the scientific community until after WW II. Before this time, upper atmospheric meteorological data was gathered primarily by the rawinsonde system, which had a maximum altitude capability of approximately 100,000 feet. As aerospace technology and emphasis rapidly increased following WW II, it became apparent that too little was known about the region of the atmosphere above rawinsonde altitudes. What effect would air density, radiation, and atmospheric motion have on aerospace vehicles? What effect would they have on the weather below? The development and successful operation of weather satellites in 1957 provided the means for gathering data above 500,000 feet. However, some method of probing the void between 100,000 and 500,000 feet was still needed. The meteorological rocket was developed to fulfill this requirement. The developmental effort centered around procuring a system which was fairly easy to handle and which was reliable but relatively economical. Since explosive components and small missile systems were involved, safety was, and continues to be, of prime concern. The solid-propellant-type rocket motor was determined to be the most feasible booster. (See fig. 20.) Various payloads, including radar, reflective chaff, telemetry packages (sondes), and passive spheres (balloon-like devices called



SOLID-PROPELLANT



LIQUID PROPELLANT

25—90

Figure 20. Two types of rockets.

ROBINS), were developed. These payloads were compatible with existing radar systems and Ground Meteorological Detection (GMD) sets. This allowed use of the same GMD for tracking both rawinsondes and rocketsondes and significantly minimized the cost of ground support equipment. By the end of 1959, sufficient testing had been completed to consider rocketsonde observing operationally feasible. In addition, participating missile ranges and affected Government agencies formed a Meteorological Rocket Network (MRN). This served to combine the efforts of all participants and resulted in significant advancements in the overall rocketsonde program. In 1962, the Air Force organized its own centrally managed network. In 1968, this network was designated "Air Force Environmental Rocket Sounding System (AFERSS)" and, in effect, replaced the old MRN. The AFERSS is comprised of USAF-operated stations plus cooperative stations that are operated by the US Army, US Navy, contractor personnel, various US governmental agencies, and the Canadian Forces. (See table 1.) The AFERSS, managed by Headquarters, 6th Weather Wing, Andrews AFB, Washington, D. C., has proven to be the most effective and economical means of providing rocketsonde data to meet USAF needs. The AFERSS has been instrumental in standardizing rocketsonde procedures and developing improved rocketsonde systems. In the following section, we will discuss the components and capabilities of the more common systems.

9-2. **Meteorological Rocket Systems.** Commonly used meteorological rocket systems are categorized into three basic families: ARCAS, LOKI, and SUPER LOKI. These terms are the common names of the solid propellant rocket motors used to boost rocketsonde payloads into the upper atmosphere. When one of the various payloads is attached to a rocket motor, the assembly becomes a rocketsonde system.

9-3. *ARCAS systems.* These were the most widely used rocketsonde systems through 1968. They include the PWN-6A and PWN-7A, as

TABLE 1

AFERSS STATIONS

METEOROLOGICAL ROCKET OPERATIONS LOCATIONS AND FUNCTIONS

LOCATION	FUNCTIONS	LAUNCH SCHEDULE (LAUNCHES/WEEK) J	F	M	A	M	J	J	A	S	O	N	D
Antiqua	T, N	3	3	3	3	3	3	3	3	3	3	3	3
Ascension	T, N **	3	3	3	3	3	3	3	3	3	3	3	3
Cape Kennedy	T, N **	5	5	3	3	3	1	1	1	3	3	3	5
Kwajalein	T, N	3	3	3	3	3	3	3	3	3	3	3	3
Ft Churchill, Manitoba, Canada	T, N	5	5	5	3	3	1	1	3	3	3	5	5
Ft Sherman, Canal Zone	N	3	3	3	3	3	3	3	3	3	3	3	3
Thule, Greenland	T, N	5	5	5	5	5	5	5	5	5	5	5	5
Cold Lake, Alberta, Canda	T, N	3	3	3	3	3	1	1	3	3	3	3	3
Ft Greely, Alaska	N	3	3	3	3	3	1	1	3	3	3	3	3
*Barking Sands, Hawaii	T, N **	5	5	5	5	5	5	5	5	5	5	5	5
*Pt Mugu	T, N **	5	5	5	5	5	5	5	5	5	5	5	5
ARIS Arnold	T	N/A											
ARIS Vandenberg	T	N/A											
Eglin AFB	T	N/A											
Vandenberg AFB	T	N/A											
White Sands Missile Range	T, N **	5	5	3	3	3	1	1	1	3	3	3	5

NOTES:

1. Functions: T = test support; N - network support.

2. Network Launch Schedule:

   a. One launch per week - scheduled on Wednesday. If unable to meet schedule, reschedule for Friday.

   b. Two launches per week - scheduled on Monday and Friday.

   c. Three launches per week - scheduled on Monday, Wednesday, and Friday.

   d. Four launches per week - Monday, Tuesday, Thursday, and Friday.

   e. Five launches per week - Daily, Monday through Friday.

*Network launches are conducted by US Navy with US Navy assets.

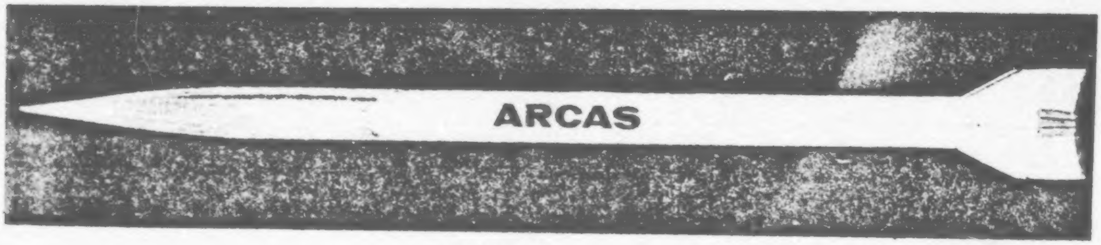
**Network launches to include one additional launch weekly (Wed) for acquisition of meteorological data to 122 km

(Ref para 3a(2) basic plan. Subject launches to be commenced in 2d qtr of CY70 if capability exists. Chg 2

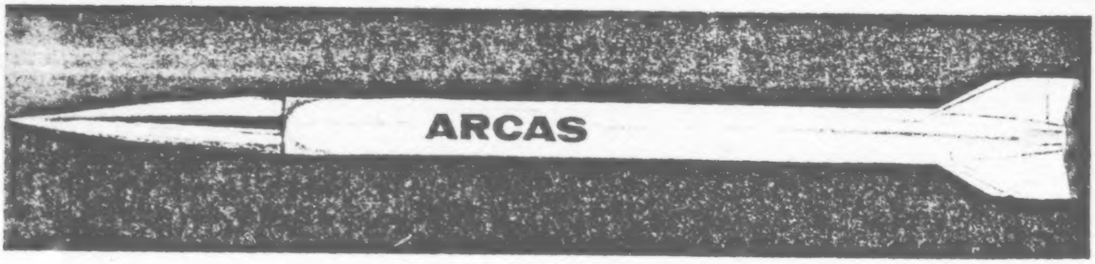
shown in figures 21, 22, and 23, all powered by standard 4.5-inch ARCAS boosters (rocket motor SR–45–AR–1). The booster is initiated by an electrically activated igniter. The motor burns for 28 seconds, ignites a 100-second delay fuse and continues to coast to an apogee (point of highest ascent) of more than 200,000 feet. The actual altitude varies with latitude, station altitude, and launch elevation. At the end of the 128-second period, the delay fuse ignites a small explosive charge that separates the payload from the spent booster. The spent booster continues on a ballistic trajectory and impacts 20 to 40 miles downrange. The payload (sensor) descends to the surface, following the path of the prevailing winds.

9-4. *LOKI systems.* Since 1968, the LOKI has become the most widely used meteorological rocket system. It costs and weighs approximately half as much as the ARCAS and has basically the same altitude and data capability. The LOKI, as shown in figure 24, is a two-stage system consisting of a 3.0-inch booster (rocket motor SR71–AD–1) and an inert dart that houses the payload. Figure 25 shows the payload ejection assembly. In LOKI systems, both the booster igniter and a 115-second time-delay fuse are initiated electrically at launch. The booster burns for approximately 2 seconds, after which it separates from the dart, becomes unstable and falls back to earth in the vicinity of the launch point. The nonpropulsive dart continues to its apogee, where the delay fuse ignites an explosive charge that forces the payload out of the dart, as shown in figure 26.

9-5. *SUPER LOKI systems.* In simpler terms, the SUPER LOKI is just a larger, improved version of the standard LOKI, as shown in figure 27. The 4.0-inch booster was designed to carry a larger dart and starute (parachute-like device) for more payload. Chaff payloads and standard datasondes have been successfully flown to date. Development of a transponder-sonde and a ROBIN payload is currently in progress. These developments will provide an altitude capability ranging from approximately 250,000 feet with a transponder instrument to near 350,000 feet with ROBIN and chaff payloads.



PWN-6A ROCKET



PWN-7A ROCKET

25—91

Figure 21. PWN 6A and 7A rockets.

9-6. *High-altitude probes.* In cases where specific requirements exist for data up to 400,000 or 500,000 feet, larger probes are available. The Viper-Dart, an even larger version of the LOKI, and the Sparrow-ARCAS, a two-stage vehicle with booster, have seen limited use on major missile ranges. However, no wide usage of these systems is contemplated within the AFERSS.

9-7. **Launch and Associated Ground Equipment.** In the following paragraphs, we will discuss the equipment required to launch the various rocketsonde systems covered in the previous paragraphs.

9-8. *ARCAS launching equipment.* The LAU–41/A rocket launcher is used to launch all standard ARCAS systems. It is a closed breech launcher and is adjustable in azimuth and elevation. The launcher consists of an *azimuth-table and base assembly, free-volume cylinder, launching tube, breech plate,* and *breech lock,* as shown in figure 28. An *auxiliary gas generator,* as shown in figure 28, is used with

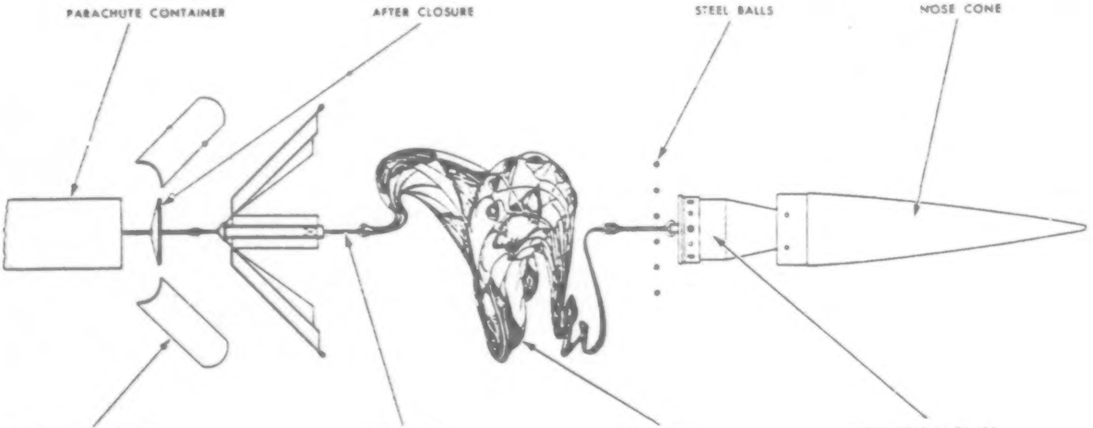

PARACHUTE CONTAINER
AFTER CLOSURE
STEEL BALLS
NOSE CONE
SPLIT INNER CYLINDER
BREAK LINE
PARACHUTE
INSTRUMENT PACKAGE AND BASE
25—92

Figure 22. PWN 6A payload.

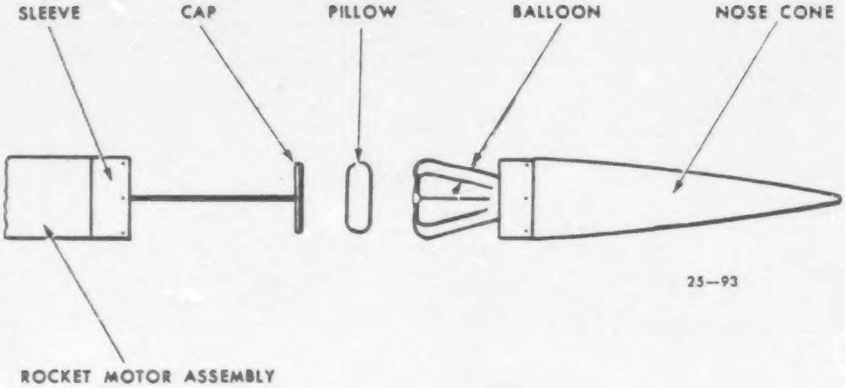

SLEEVE
CAP
PILLOW
BALLOON
NOSE CONE
25—93
ROCKET MOTOR ASSEMBLY

Figure 23. PWN 7A payload.

the launcher when increased launch velocities are desired.

9-9. *LOKI/SUPER LOKI launching equipment.* The LAU–66/A rocket launcher is used to launch all LOKI and SUPER LOKI vehicles. It consists of a *launcher base, pedestal assembly, support assembly,* and *rail assembly,* as shown in figure 29. The standard rail assembly is replaced with a larger one to launch SUPER LOKI systems. The LAU–66/A is an open breech variable setting launcher with four helical rails, shown set up in figure 30. The rails impart a stabilizing spin of approximately 10 revolutions per second as the vehicles leave the launcher. The DCU–147/E Firing Station was specifically designed for use with PWN–8B systems. However, it is compatible with any LOKI or SUPER LOKI system. The firing station is used to test the instrument (datasonde) and to initiate the rocket motor igniter and dart tail delay fuse by remote control.

9-10 High-altitude probes such as the Viper-Dart and Sparrow-ARCAS are launched from rails that are adaptable to various types of mounts. Since these systems are normally launched from major missile installations, existing probe launch facilities such as NIKE, SCOUT, etc., are generally used.

9-11. **Wind Weighting and Ballistics.** Four important factors must be considered in discussing wind weighting and ballistics. *First,* all meteorological rockets become nonguided, nondestruct missile systems after they are launched. *Second,* a rocketsonde system cocks *into* the wind during the powered phase of flight because of the vehicle's configuration and the forces affecting it. A tailwind tilts the vehicle up, a headwind forces it down. *Third,* the missile flight and debris impact must be contained within designated range limits. *Fourth,* if the system does not go where it is supposed to go, loss of life, personnel injury, property damage, or—at the very

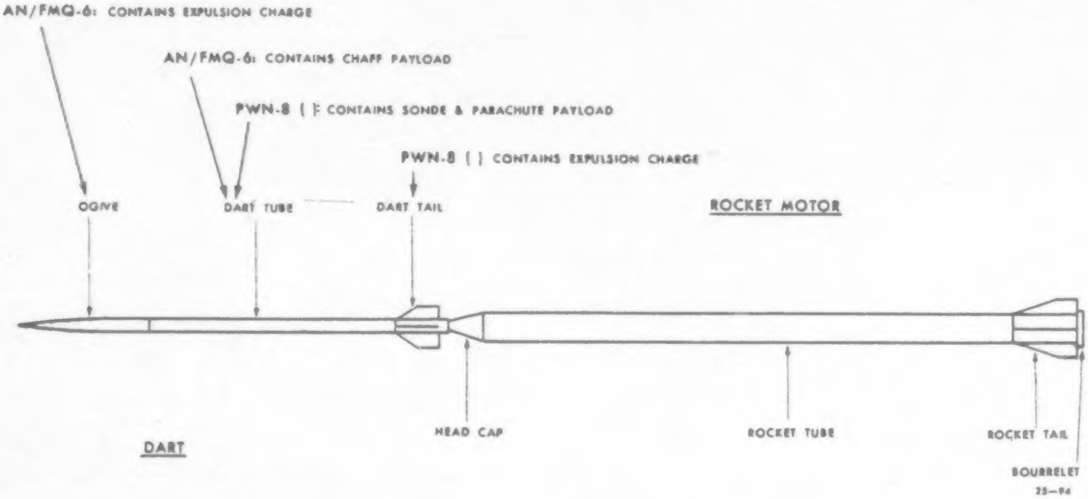

AN/FMQ-6: CONTAINS EXPULSION CHARGE
AN/FMQ-6: CONTAINS CHAFF PAYLOAD
PWN-8 ( ): CONTAINS SONDE & PARACHUTE PAYLOAD
PWN-8 ( ) CONTAINS EXPULSION CHARGE
OGIVE
DART TUBE
DART TAIL
ROCKET MOTOR
HEAD CAP
ROCKET TUBE
ROCKET TAIL
DART
BOURRELET
25—94

Figure 24. LOKI rocket system. AN/FMQ–6 and PWN–8( ).

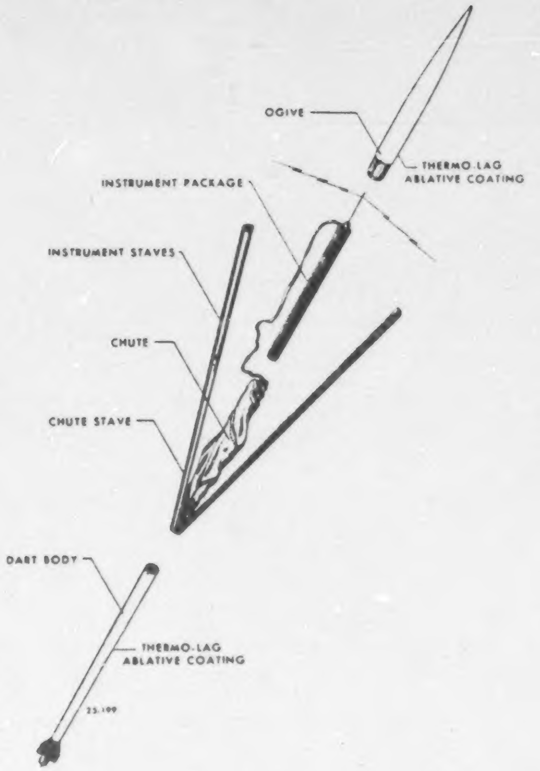


Figure 25. LOKI payload ejection assembly.

least—failure to obtain desired data, could result. Consequently, these factors must be compensated for before the vehicle is launched. After launch, it's too late!

9-12. **Launch Operations.** For efficient and accident-free rocketsonde operations, a detailed countdown checklist is prepared and used. A different countdown is required for each launch site and each rocketsonde system. The checklist specifies *what* will be done, *when* it will be done, and *who* will do it. Depending upon launch schedule and location, prelaunch activities may begin as early as 1 to 2 days before the launch. When sonde-type payloads are involved, they are thoroughly checked in sufficient time to avoid launch delays. All personnel and agencies involved in the operation are notified far enough in advance to make the necessary preparations.

9-13. *Uncrating and handling.* You will receive rocketsonde components in various types of containers, as shown in figures 31 through 36. The containers can be opened by removing the bands, screws, nails, or tape which holds them together. If special instructions apply, you can find them on the container or in the applicable TO or TM. Containers of explosive items are clearly marked showing the *type* and *quantity*. All items are normally stored and transported in their original containers. Rocket motors and assembled rocketsonde systems are *always* handled by *two men*. All other explosive items are handled in accordance with the provisions of AFM 127-100, *Explosives Safety Manual*. The basic principle to remember is this: Expose the least number of personnel to the least amount of explosives for the least amount of time possible. Persons who handle explosive items must wear safety helmets, safety shoes, and clothing which will not produce static. They are *not* permitted to wear rings, watches, etc., or have other exposed metallic objects on their persons while handling explosives.

9-14. *Prelaunch testing.* Here we must consider three major areas—payloads, firing circuits, and electro-explosive devices (EEDs).

a. Instrument payloads for ARCAS systems (ARCASONDE 1A and DMQ-9) are checked in a baseline check set, similar to the way in which radiosondes are preflighted. Figure 37 is an example of a baseline check record. LOKI instruments (datasondes) are changed and tested for signal strength, modulation, and operation of the reference switching circuit. Instrument performance is rechecked on the launch pad before the system is assembled (pad check). The final check is made shortly before launch, after the system is loaded into the launcher (tube check). Figure 38 is an example of this check on the recorder record.

b. Firing circuit checks are extremely important. Have you ever had a gun misfire, or fire accidentally? We carefully and thoroughly check all aspects of the electrical circuits to prevent such an occurrence in rocketsonde operations. The firing panel, firing lines, and launcher are checked to insure that the proper voltage gets to the proper place (voltage checks). Additional tests are made to check for stray voltage (zero voltage check), before hooking up igniters, separation devices, and firing lines.

c. Igniters and separation devices are not selective. They can be activated by electrical current, static electricity, or radiofrequency (RF) energy. An authorized test area must be used when testing these items for circuit continuity and resistance. Only specifically designated test equipment is used.

9-15. *Field assembly.* Specific instructions are contained in applicable TOs and TMs. Assembly of the PWN-6A and PWN-6B payloads consists of installing and activating a battery in the instrument and mating a parachute to the sonde and ogive (nose cone), as shown in figure

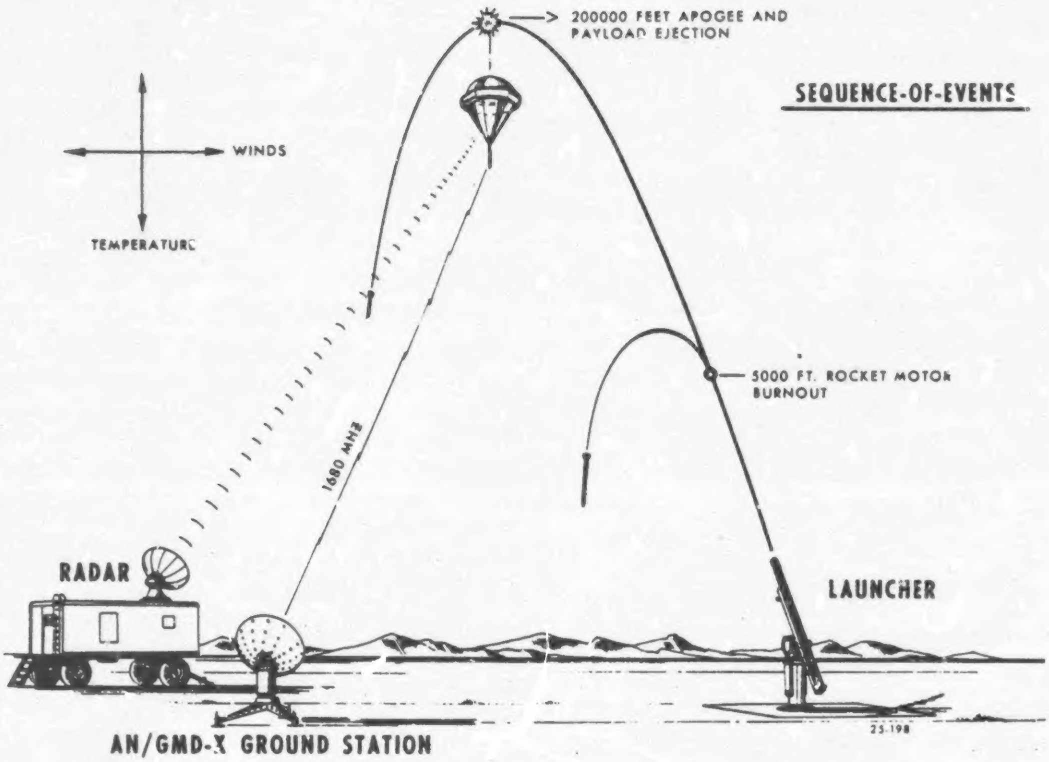
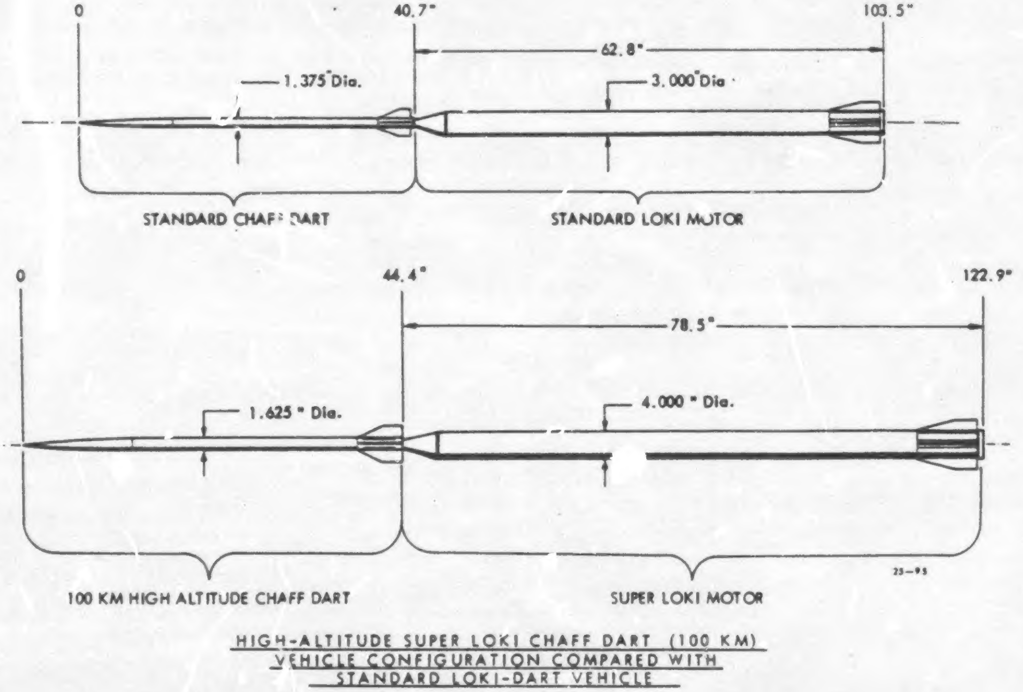

200000 FEET APOGEE AND PAYLOAD EJECTION
SEQUENCE-OF-EVENTS
WINDS
TEMPERATURE
1680 MHZ
5000 FT. ROCKET MOTOR BURNOUT
RADAR
LAUNCHER
AN/GMD-X GROUND STATION
25-198

Figure 26. Meteorological probe, PWN 8( ), operation.


0
40.7"
103.5"
62.8"
1.375" Dia.
3.000" Dia
STANDARD CHAFF DART
STANDARD LOKI MOTOR
0
44.4"
122.9"
78.5"
1.625" Dia.
4.000" Dia.
100 KM HIGH ALTITUDE CHAFF DART
SUPER LOKI MOTOR
25-95

HIGH-ALTITUDE SUPER LOKI CHAFF DART (100 KM)
VEHICLE CONFIGURATION COMPARED WITH
STANDARD LOKI-DART VEHICLE

Figure 27. SUPER LOKI system.

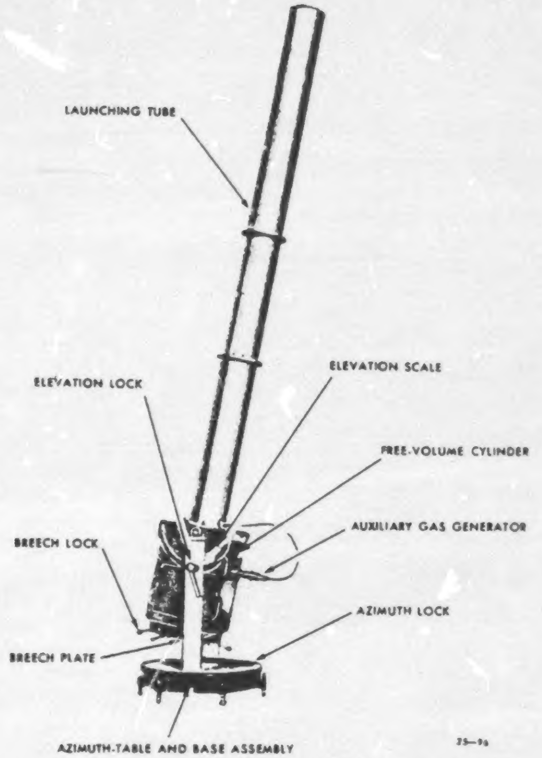


Figure 28. LAU–41/A rocket launcher.

39. All ARCAS payloads are attached by screwing them on the forward end of the rocket motor. LOKI darts are assembled as shown in figure 40. Figure 41 illustrates assembly of the SUPER LOKI vehicle.

9-16. *Loading and launching.* Figure 42 illustrates ARCAS loading procedures. The four styrofoam spacers are used to center and stabilize the system until it leaves the launch tube. (See fig. 43.) LOKI systems are loaded so that the dart fins ride on the launcher rails. (See fig. 44.) After loading both ARCAS and LOKI systems, a "stop pin" is engaged to prevent the rocket from sliding back when the launcher is elevated. The launch conductor insures that the range is clear, that all checks have been completed, and that everyone is ready before activating the launch switch.

9-17. **Tracking Requirements.** Rocketsondes are tracked by radar and/or rawinsonde tracking equipment from launch through descent to 25 kilometers. Various types of radar systems, including FPS–16, TPQ–18, M–33 MOD II, CAPRI and SCR–584, have been used for radar tracking. The GMD–1, GMD–2A, and BMD–4 rawin sets are used for tracking sonde payloads. Radar data are normally displayed at specified time intervals (data points) on radar plot charts or presented in the form of digital time, azimuth, elevation, and slant range (TAER) values. Some radar systems convert the TAER data into a digital printout which includes altitudes and winds. Temperature data are recorded on a TMQ–5 recorder in basically the same manner as in rawinsonde. Both radar and GMD support is needed when ARCASONDE 1A and standard datasonde instruments are flown. ROBIN and chaff payloads are tracked by radar. A GMD–4 is used to track transponder-sondes (DMQ–9).

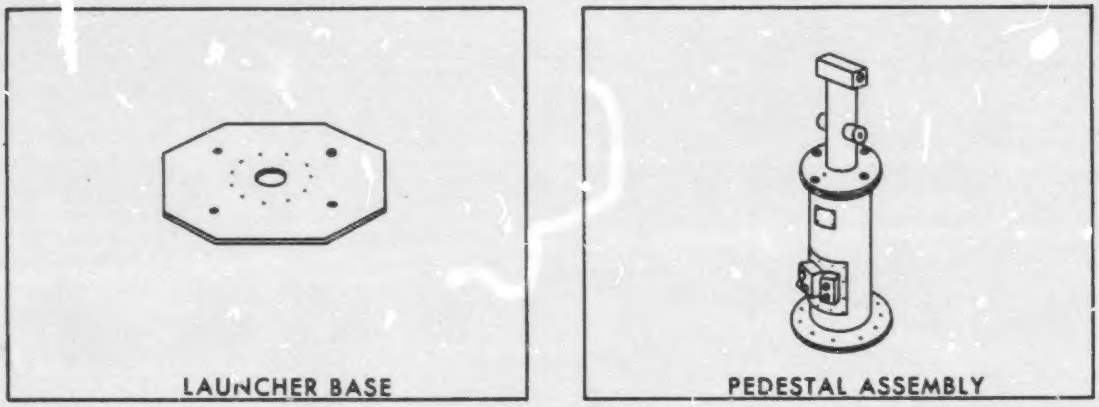
9-18. **Data Evaluation and Reduction.** Procedures for evaluating and reducing rocketsonde data differ, depending upon the ground and flight equipment used. However, the two basic methods used are *manual* and *electronic data processing* (EDP).

9-9. *Manual processing.* A time versus altitude relationship (T/A) is constructed from values derived from the radar plot chart, TAER data or GMD–4 output. Unless altitude values are provided, you will have to compute them mathematically (slant range times the sine of the elevation angle). Windspeeds and directions are computed from the ground range or horizontal distance out (HDO) for each data point (slant range × the cosine of the elevation angle). Wind directions and speeds can then be determined in basically the same manner as in rawinsonde. Temperatures traces on the TMQ–5 recorder record are illustrated in figure 45. The traces are carefully evaluated and levels are selected according to criteria specified in the *Interim 6 WWg Rocketsonde Operations Manual.* After all data has been evaluated and verified, a reduced data graph is constructed as shown in figure 46. All plotted values are carefully double-checked and verified before data are extracted for coding and dissemination.

9-20. *Electronic data processing (EDP).* Where EDP is available, raw or partially reduced data are prepared in specified formats and fed into computers. The computers have been programmed to perform all required functions and to print out the data including a coded message.

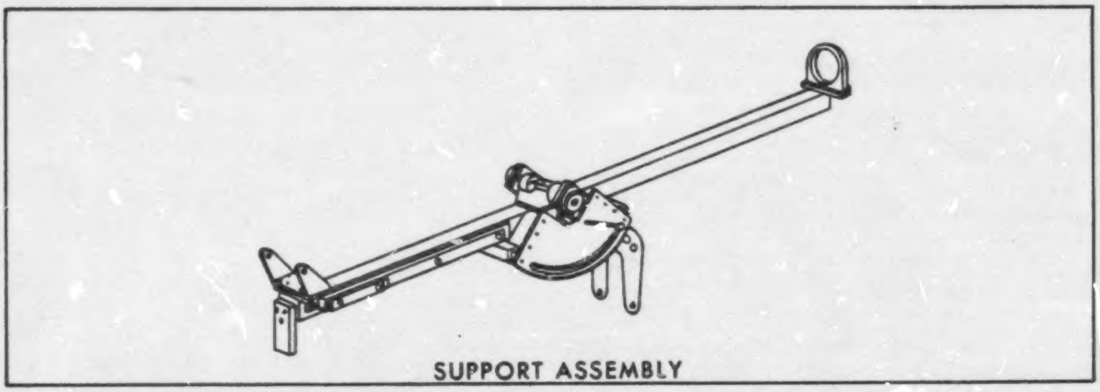
9-21. **Encoding and Disseminating Data.** Reduced rocketsonde data are converted to a rocketsonde code message for teletype transmission. Stations that launch on a scheduled, network support basis (see table 1) transmit ROCOB bulletins according to established teletype transmission schedules. Other rocketsonde observations may be transmitted on an unscheduled basis.

9-22. *Rocketsonde code.* Foldout 1, printed and bound in the back of this volume, is an example and explanation of rocketsonde code. When data are reduced manually, the reduced

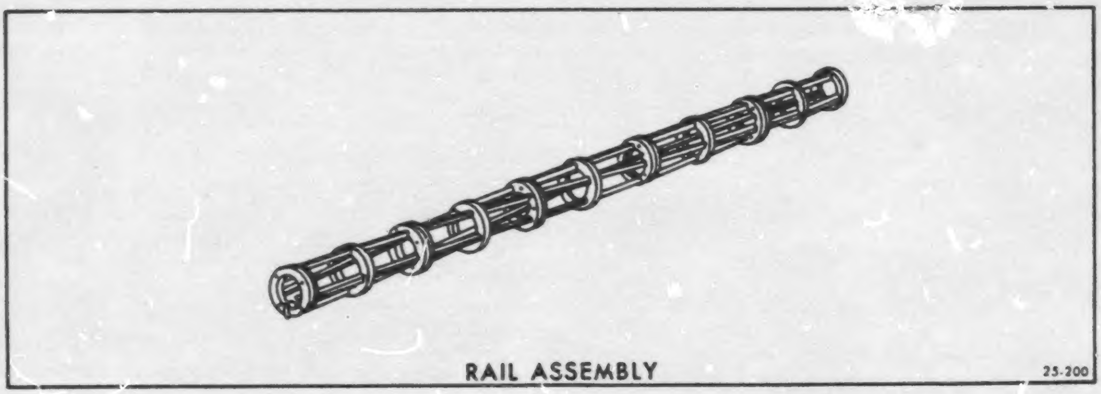


LAUNCHER BASE

PEDESTAL ASSEMBLY



SUPPORT ASSEMBLY



RAIL ASSEMBLY

Figure 29. Components of the LAU-66/A rocket launcher.

458

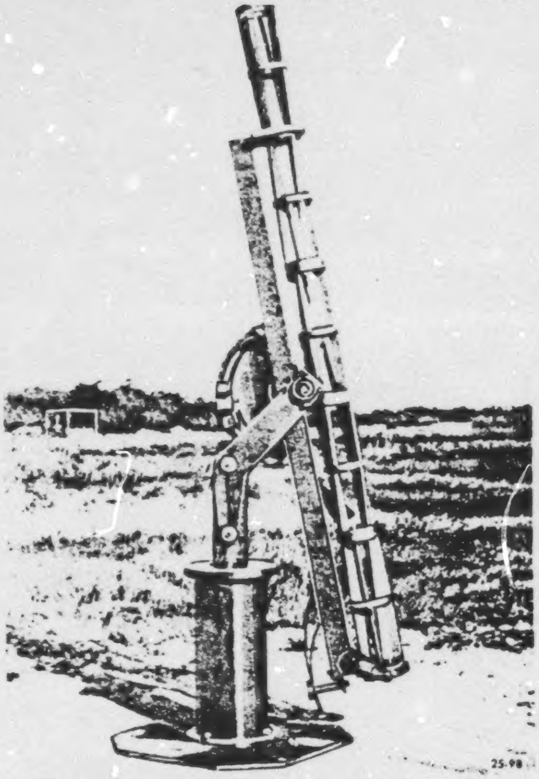


Figure 30. LAU-66/A rocket launcher set up.

data graph is used to select mandatory levels every 5 kilometers (KM), starting at 25 KM. However, significant levels can be reported only to the nearest whole KM. The solidus is used for any missing data item. When EDP is provided, the computer prepares the ROCOB code message.

9-23. *Records disposition.* All rocketsonde and related records are forwarded the USAF Environmental Technical Applications Center (ETAC) in Washington, D.C. for quality control and archiving. Records from a conjunctive rawinsonde observation, taken within 4 hours before or 2 hours after the launch, are also forwarded with the rocketsonde records.

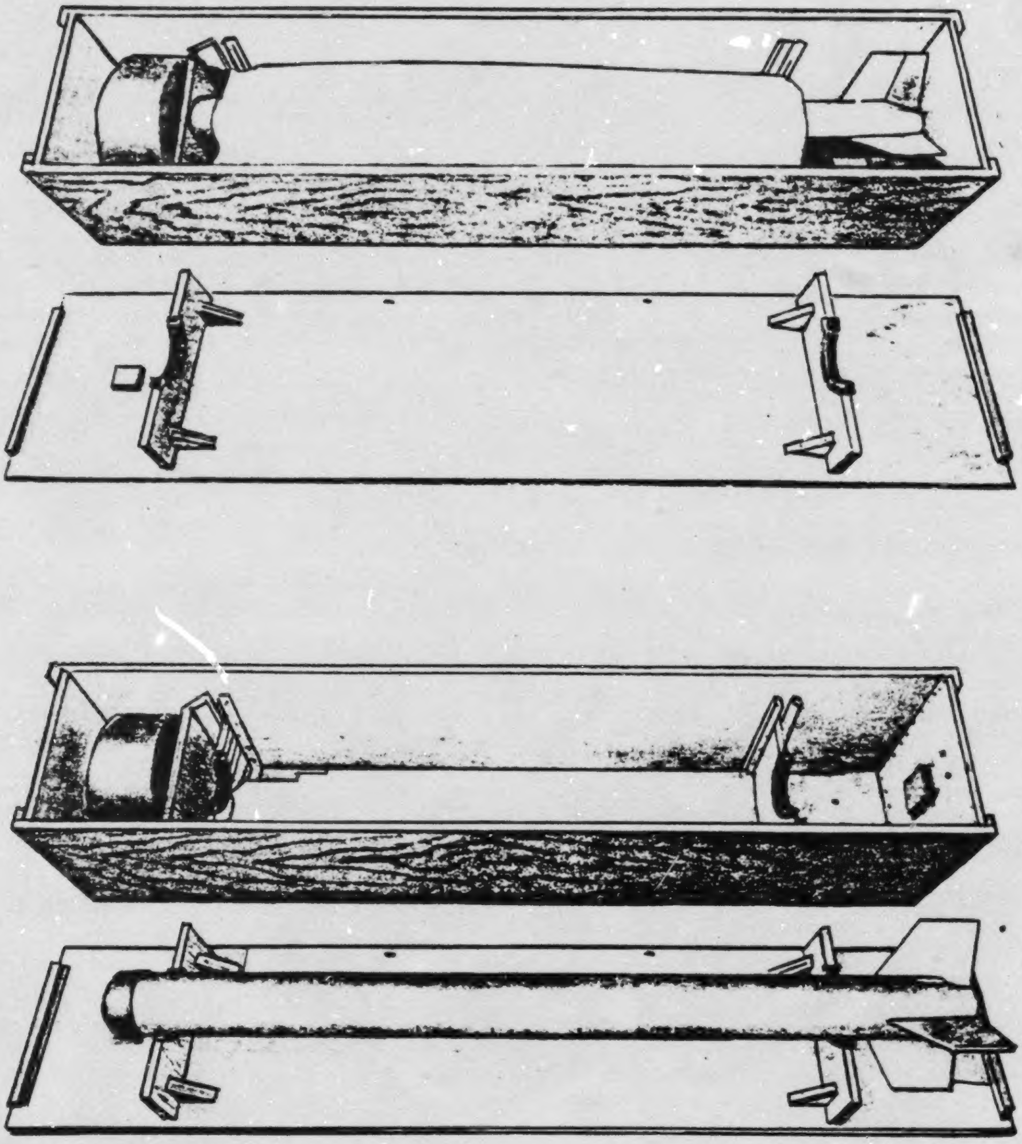
10. Dropsonde Observations

10-1. Dropsonde is a method of obtaining vertical weather data from an aircraft in flight. Dropsonde observations are made by airborne weather observers assigned to weather reconnaissance squadrons within the 9th Weather Reconnaissance Wing. These airborne weather observers (AWOs) make up part of the weather team whose primary mission is to collect horizontal and vertical weather data from remote or inaccessible areas of the world. There are usually two or three members assigned to each weather team. These teams consist of an aerial reconnaissance weather officer (ARWO) and one or two aerial weather observers (AWOs). These team members daily collect weather data over the Atlantic, Pacific, and Arctic Oceans. They fly in WC-130B/E and WE-135B aircraft at altitudes from 1,500 to 50,000 feet, and at speeds from 200 to 600 miles per hour. They have some unique problems. The weather elements that they report on are above, below, and all around them, no matter where they travel. In addition to being professional weather personnel, they must also be professional aircrew members. All flights are a challenge to the AWOs. Some of the problems they encounter are changing mission requirements, communication difficulties, crewmember duties, and equipment failures. This requires every weather team member —especially the AWO—to be a flexible, clear-thinking, quick-thinking individual who can respond to the variety of situations he faces when making dropsonde observations.

10-2. **The AN/AMT-13 Radio Dropsonde.** Since the early beginnings of aerial weather reconnaissance (Wx Recon), various types of dropsondes have been used. Today, without the AN/AMT-13 compact electronic package, dropsonde would not exist. The AN/AMT-13 radio dropsonde (T-13) is the heart of the dropsonde observation; it is used throughout the 9th Weather Reconnaissance Wing. The general specifications of the T-13 are:

a. Diameter 3.5 inches.
b. Length 18 inches.
c. Weight 4.7 pounds.
d. Radiofrequency 402.5 ± 1.5 Hz.
e. Battery life (fully charged) 20 min.
f. Measurement range.
  (1) 100 to 1060 mb.
  (2) +55° C. to −85° C.
  (3) 5 to 100 percent humidity.

10-3. Figure 47 shows a T-13 dropsonde (parachute unpacked) before it has been prepared for a weather mission. After the AWO unpacks the dropsonde, he must carefully prepare it for its one-time, one-way drop to the surface of the ocean or ice pack. First, he must attach the sensor board, containing the temperature and humidity elements (see fig. 48) to the bottom of the dropsonde (fig. 49). Then he must check the unit to be sure that it functions properly. To do this, he checks the dropsonde's batteries and charges them if necessary. He also makes a complete check of the electronic circuitry. After this has been done, the AWO does the baseline check to determine whether or not the temperature and humidity sensors operate within the specified tolerances. In making this



25-217

Figure 31. Unpacking rocket motors and igniters.

check, he compares the readings of the dropsonde against a standard (under controlled conditions) and records the results on forms for this purpose. All the paperwork pertaining to the dropsonde is placed with it until the instrument is taken on a weather mission. However, this is only one step in preparing for an aerial weather reconnaissance mission. Another indispensable step is preflighting the aircraft.

10-4. **Preflight of the Aircraft.** Would you be willing to go to work at 0100 in the morning to prepare for a shift that starts at 0300 in the morning and continues for 19½ hours straight with no breaks? An NCOIC who required this of his people would probably receive some remarks concerning his pedigree. This is the type of dedication, though, that is required of every aerial weather observer. He must report to the

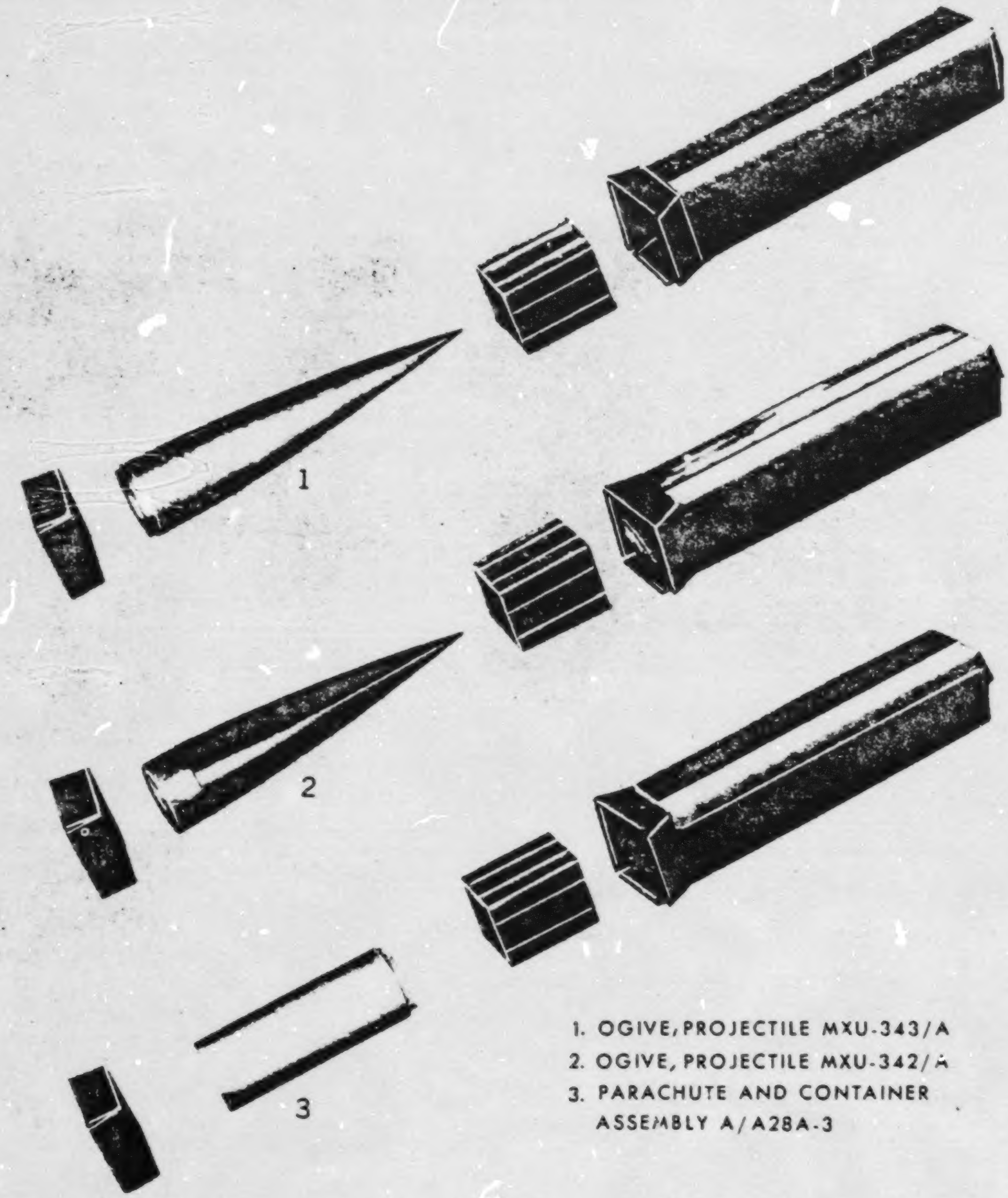

1
2
3
1. OGIVE, PROJECTILE MXU-343/A
2. OGIVE, PROJECTILE MXU-342/A
3. PARACHUTE AND CONTAINER ASSEMBLY A/A28A-3
25—221

Figure 32. Unpacking payload components.

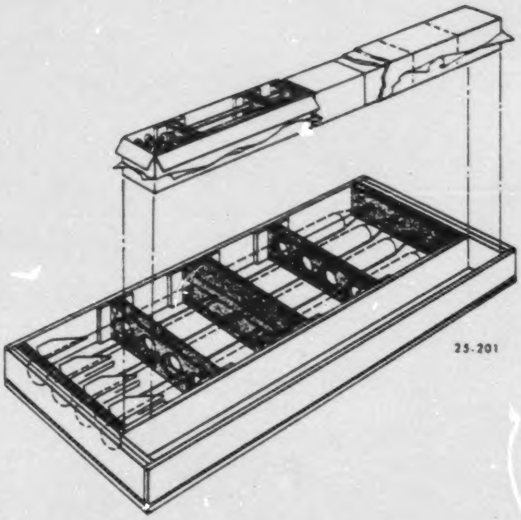


Figure 33. Explosive components container.

aircraft 2 hours before takeoff to preflight the aircraft and meteorological systems. Of all the things he might do during the weather mission, the 2 hours allotted to preflight are the most important in his life. Why? Because his weather station is a mobile, high-flying, fast-moving platform. If that platform decided to quit about 1000 miles from land because he overlooked something, he might not have a second chance. Every crewmember is responsible for the safe conduct of the mission, and that includes the AWO.

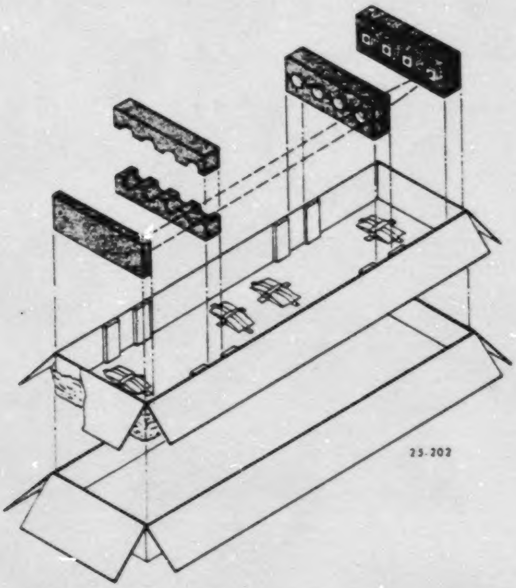


Figure 34. Inert components container.

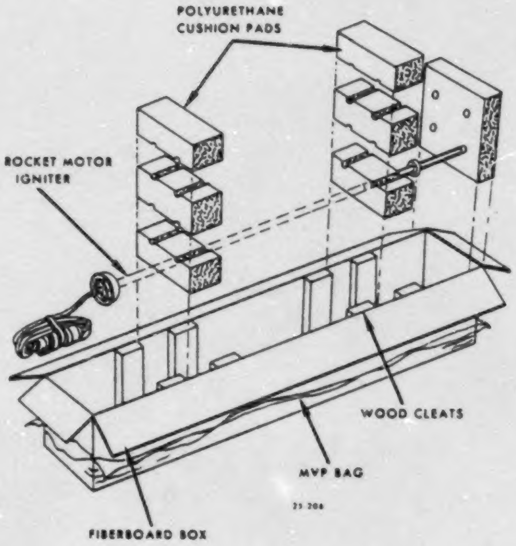

POLYURETHANE
CUSHION PADS
ROCKET MOTOR
IGNITER
WOOD CLEATS
MVP BAG
25-204
FIBERBOARD BOX

Figure 35. Unpacking igniter assemblies.

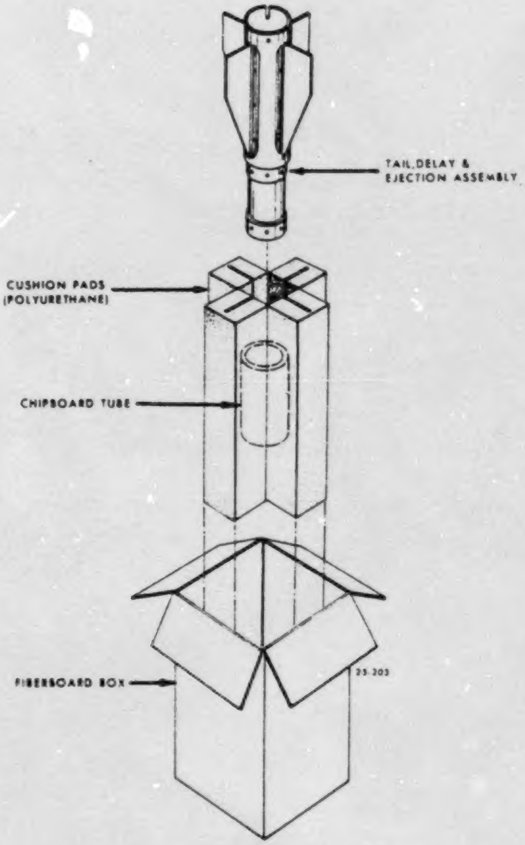

TAIL,DELAY &
EJECTION ASSEMBLY
CUSHION PADS
(POLYURETHANE)
CHIPBOARD TUBE
25-203
FIBERBOARD BOX

Figure 36. Unpacking tail assemblies.

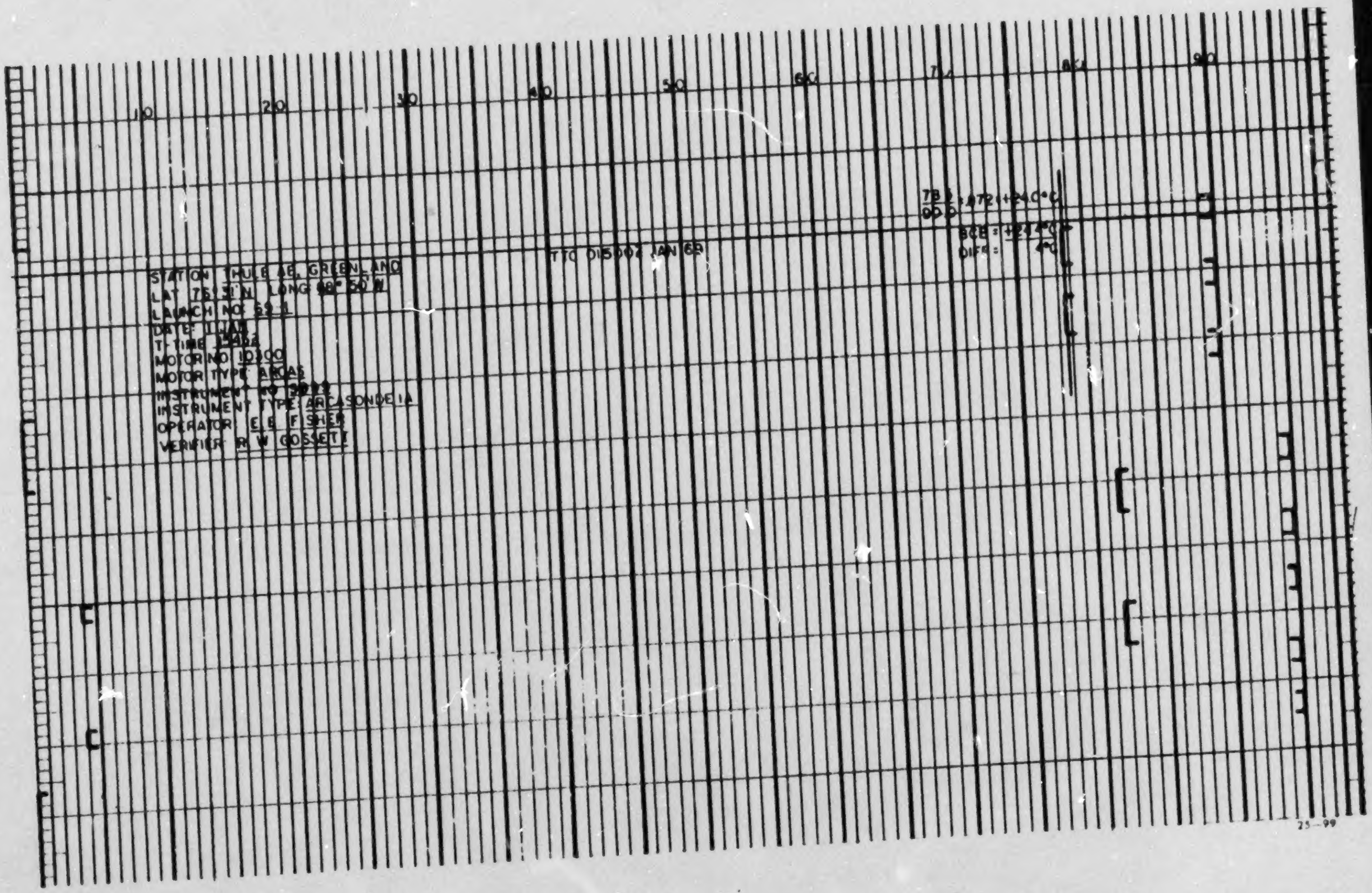


Figure 37. Baseline check record.

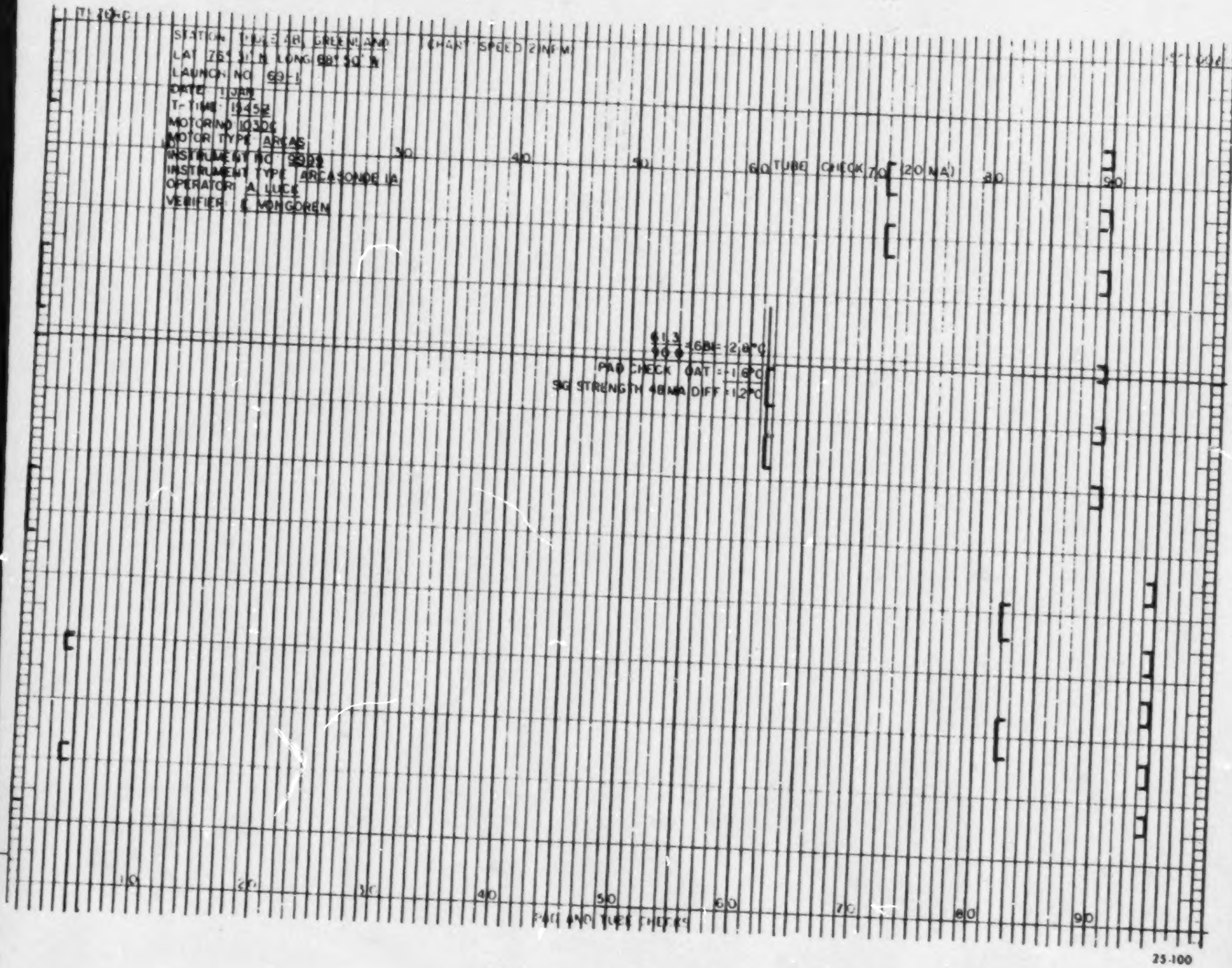


Figure 38. Recorder record.

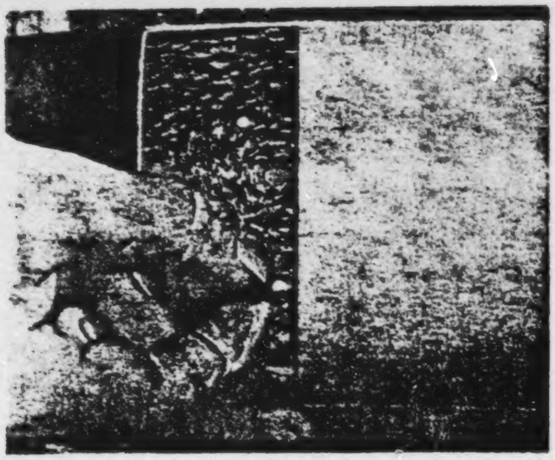


Figure 39. Assembly of PWN-6A/B payloads.

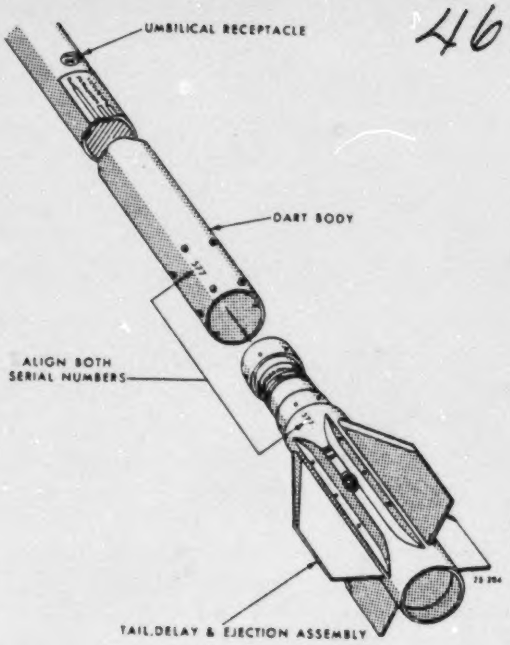

UMBILICAL RECEPTACLE
DART BODY
ALIGN BOTH SERIAL NUMBERS
TAIL,DELAY & EJECTION ASSEMBLY
25.204

Figure 40. LOKI dart.

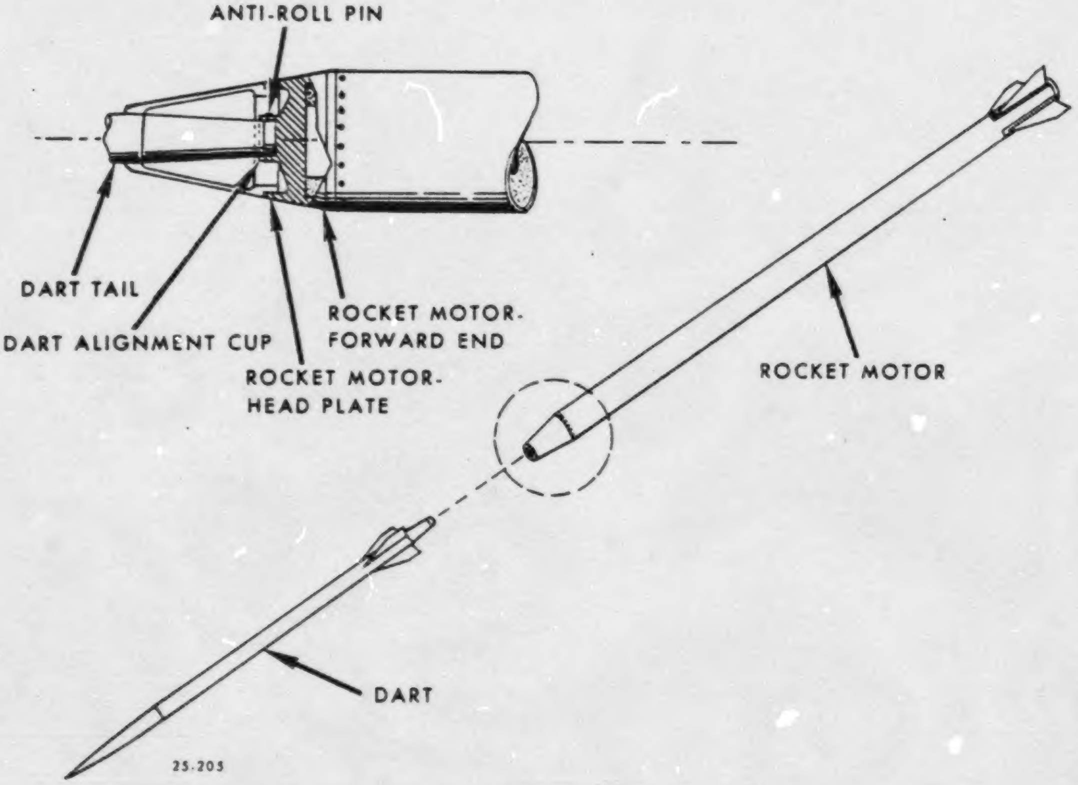
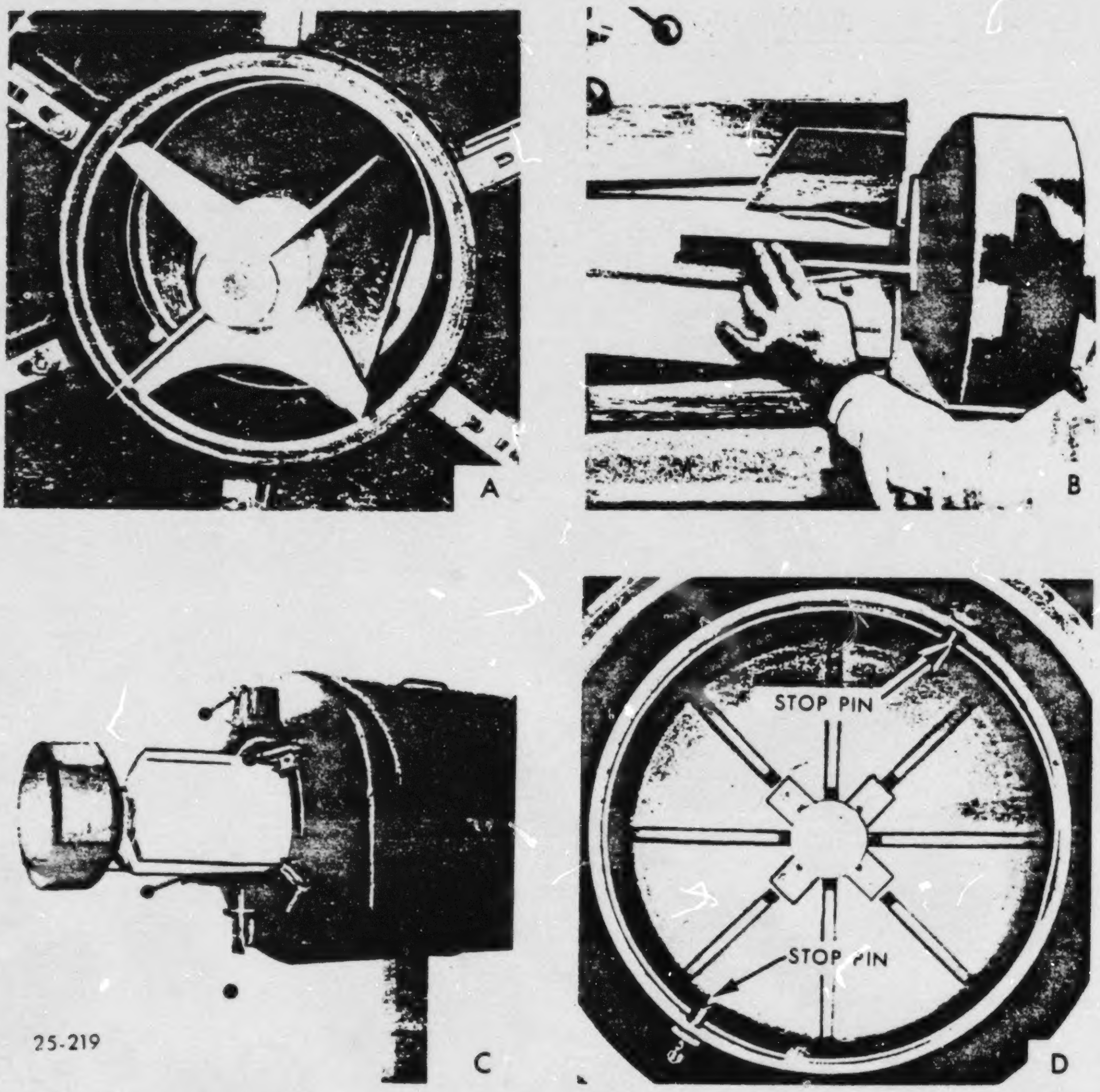

ANTI-ROLL PIN
DART TAIL
DART ALIGNMENT CUP
ROCKET MOTOR-HEAD PLATE
ROCKET MOTOR-FORWARD END
ROCKET MOTOR
DART
25.205

Figure 41. SUPER LOKI vehicle.



A. Rocket inserted in launching tube.
B. Placing spacer in launcher.
C. Rocket placed on spacer.
D. Stop pins engaged on launcher.

Figure 42. ARCAS loading procedures.

10-5. *WC-130 systems.* Preflight is usually started by checking the aircraft first. An AWO assigned to a WC–130 (see fig. 50) assists the flight mechanic in checking the control surfaces and propeller controls on the aircraft. After that, his next major considerations are the security of the cargo compartment and the availability of emergency equipment. Once he has inspected the major flight safety items, then he can return to being a weather observer. At this point, the AWO starts to the outside of the aircraft to assist the rest of the crew in starting the engines and getting off the ground. Once the engines are started, the AWO is the last one on the airplane and is responsible for closing all the doors before the aircraft takes off.

10-6. *WC–135 systems.* In contrast, the AWO's duties on the WC–135 (fig. 51) are quite different from those on a WC–130, yet somewhat alike. Now, how can that be? Well, the crew is still responsible for the safe conduct of the mission, but the duties of the AWO are shortened in one area and expanded in another. The AWO on the WC–135 has no responsibility for assisting the flight mechanic during any control surfaces or engine checks. Almost all his aircraft preflight consists of checking emergency equipment and briefing passengers. This might not seem important to you, but remember that in an emergency it might be necessary to ditch the aircraft in the water 1000 miles from nowhere. The emergency gear carried on the aircraft can mean the difference between life and death for those on board.

10-7. The preflight of the meteorological system on the WC-135 is a very technical procedure. The procedure takes approximately 30 to 40 minutes for a fully qualified AWO. He has the same responsibilities as the AWO on a WC-130: to have the proper forms, equipment, and T-13 dropsondes on hand. As you can guess, the AWO on each aircraft has a very important position in the aircrew. His advice and skill is sought both as a weather observer and as an aircrew team member. This is why the AWO must constantly strive to keep up to date in both areas. This is quite a task because changes are taking place constantly in the development of aircraft and of airborne meteorological systems.

10-8. **Airborne Meteorological Systems.** The two airborne meteorological systems in use today are different from those of just a few years ago. In the short span of 5 years, AWS has used four different weather systems and is in the process of acquiring yet another one. The AN/AMQ-25 and the AN/AMQ-29 are the latest systems in use. The AN/AMQ-29 is still being improved, although it is an operational system. The AN/AMQ-25 has been in use during the past 5 years, but is also still undergoing changes. Because of the newness of the AN/AMQ-29, the AN/AMQ-25 is the system we will discuss in great detail.

10-9. **AN/AMQ-25.** This system is the older of the two systems presently in use. It came into AWS inventory in 1965 along with the WC-135B aircraft on which it is installed. Even for its age, the system still offers a challenge to the airborne weather observer. It is composed of five specific subsystems within the main system. The five subsystems are:

- Horizontal (flight level).
- Vertical (dropsonde).
- Data handling.
- Control conversion.
- Teletype.

10-10. *Horizontal subsystem.* This subsystem includes equipment which directly or indirectly is involved in the collection of horizontal weather data. Contained within this subsystem are components which feed position, wind, pressure, time, and heading into the system for output to the airborne weather observer. By selecting the proper switches on the dispenser control panel (see fig. 52), the observer can call upon the CP-821/AMQ-25 digital data computer (see fig. 53) to process and output the first eight groups of RECCO Code when the mission requires it. In instances when the computer is out of operation, the observer has several options to follow. He can manually compute the data, using the manual data indicators shown in figure 52, or he can have the system direct its output of raw unprocessed data to the teleprinter. Thus the observer has three methods to acquire his horizontal data for transmission to the ground and using agencies. All three methods are used when operational on each flight to control the quality and verify the output of the AMQ-25 system.

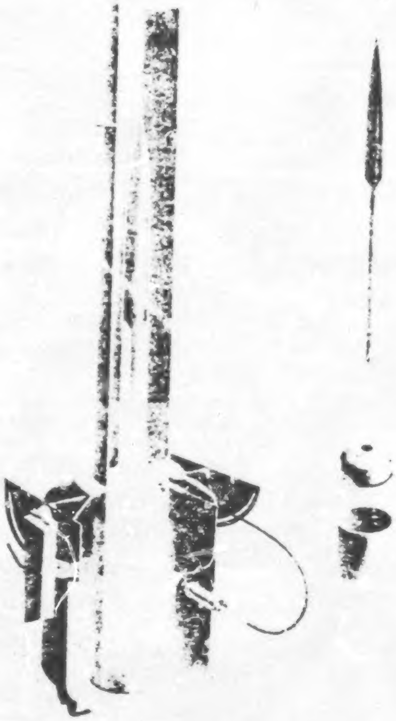


Figure 43. Launch tube and spacers.

10-11. *Vertical subsystem.* This subsystem is the one of primary interest to the AWO. It includes the equipment necessary for the vertical sampling of the atmosphere below the aircraft. The components of this subsystem consists of all the equipment necessary to drop, sense, and receive all signals from the T-13 radio dropsonde, and pass them on to the data handling subsystem. The dropsonde is placed in the dropsonde dispenser ejection chute (see fig. 54) with the sensor end down. The chamber is controlled from either the main Q-25 console (see fig. 52) or the remote dispenser control panel shown in figure 54. After the sonde is turned on and ejected, signals from the sonde are transmitted back to the

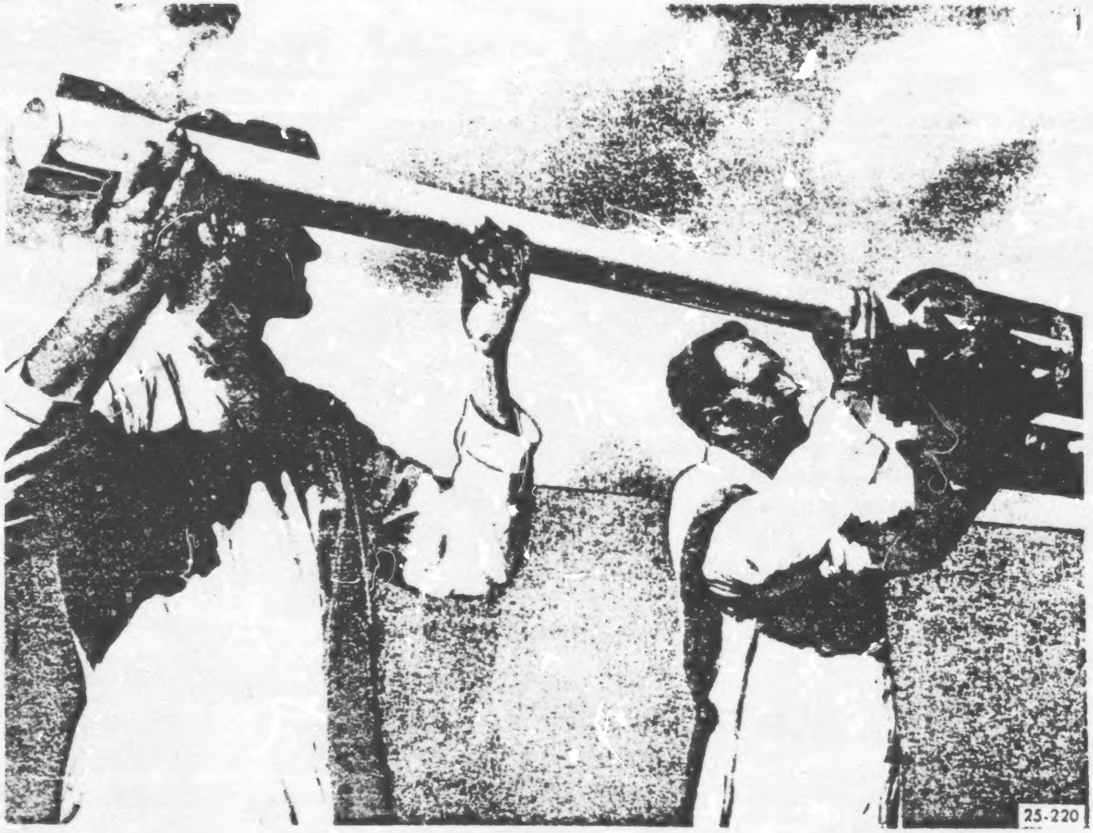


Figure 44. Loading the LAU–66A rocket launcher.

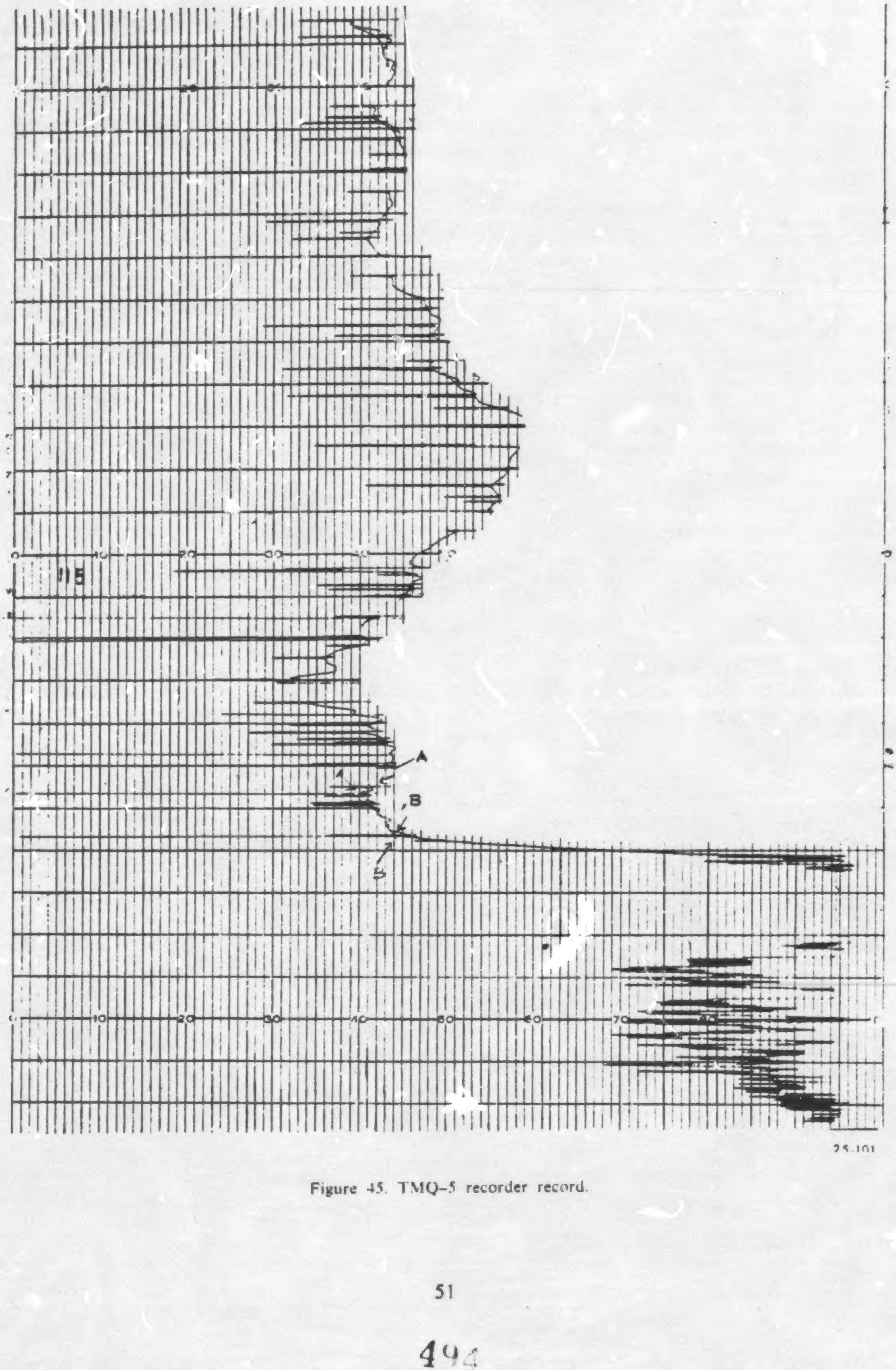
aircraft. The receiver accepts these signals and sends them on to the data-handling subsystem. This system's job is an extremely important part of the vertical run.

10-12. *Data-handling subsystem.* This subsystem is somewhat akin to a middleman. The data-handling subsystem receives all data from the horizontal and vertical subsystems. In the data-handling subsystem, the data is processed by two electronic components and sent forward to the control-conversion subsystem.

10-13. *Control-conversion subsystem.* The control-conversion subsystem receives semiprocessed raw data from the data-handling subsystem. Here it is processed by either one of two modes, as selected by the airborne weather observer. Under one mode (the computer mode), the processed raw data is sent by the CD–821/-AMQ–25 digital data computer, where it is again processed and the output sent to the teletypewriters through the buffer-converter. The buffer-converter deserves special mention because it acts as a temporary storage unit. The computer can operate at the rate of 1000 words per minute, but the typewriter can print at only 100 words per minute. The most desirable thing about computer processing is that the data output is in the processed coded form. The only thing that must be done to the output is to check its quality.

10-14. If the observer does not select the computer mode, he can use the second method. Under this method, the processed vertical raw data is sent directly to the buffer-converter for delayed output to the teletypewriter in the same manner as in the computer mode. However, the digital vertical raw data must be manually reduced by the airborne observers. The processing of this digital data record to the raw parameters of temperature, humidity, and pressure is a long and complicated procedure which takes the airborne weather observer many hours to learn. For the purpose of this course, we will not become involved in this process.

10-15. *Teletype subsystem.* This system handles all the primary outputs from the Q–25 system. Its principal components consist of the teletypewriter and reperforator/transmitter. The teletypewriter handles all the outputs and printouts from the buffer-converter and prints the data in the standard format on teletype paper. At the same time, the observer can, through



25-101

Figure 45. TMQ-5 recorder record.

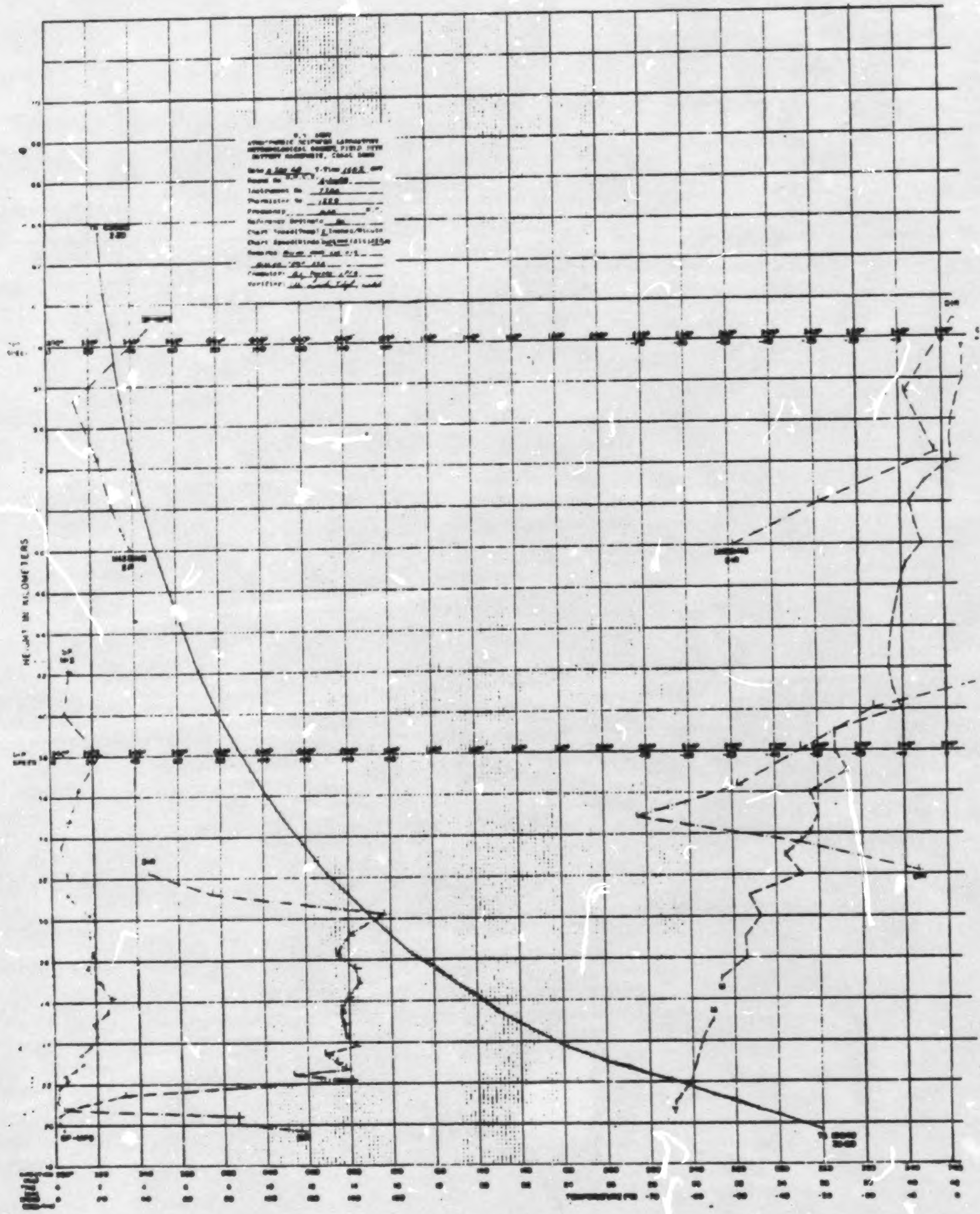


Figure 46. Reduced data graph.

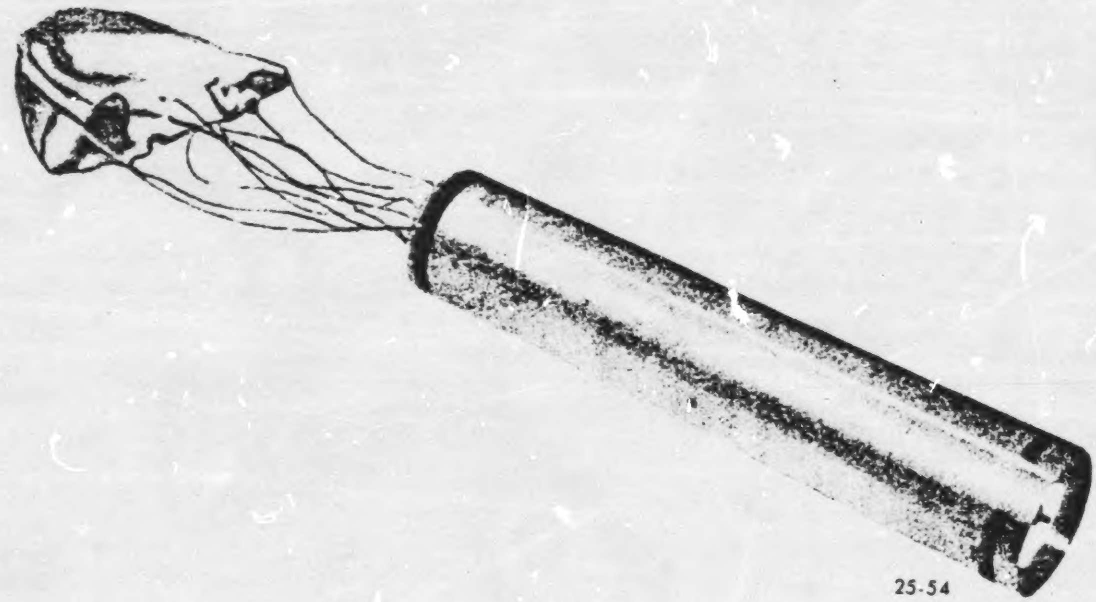


Figure 47. AN/AMT-13 radio dropsonde.

the selection of switches, have the buffer-converter send signals to the reperferator/transmitter and have that machine cut a teletype tape for transmission to the ground. After the teletype tape is checked for quality, the operator, using the aircraft radio, contacts a ground station and establishes a radio link. The teletype data is then sent to the ground and within minutes is in the using agencies' hands. Another system for processing dropsonde data is the AN/AMQ-29 system used in WC-130 aircraft.

10-16. **AN/AMQ-29.** This dropsonde system presently in use is strictly a vertical sounding system. This system is similar to the vertical subsystem of the Q-25. The same dropsonde dispenser, receiver, and control panels are used in both systems (see figs. 55 and 56). However, in the operation of the Q-29, once the sonde is ejected and transmitting signals back to the aircraft, these signals are measured, processed electronically, and

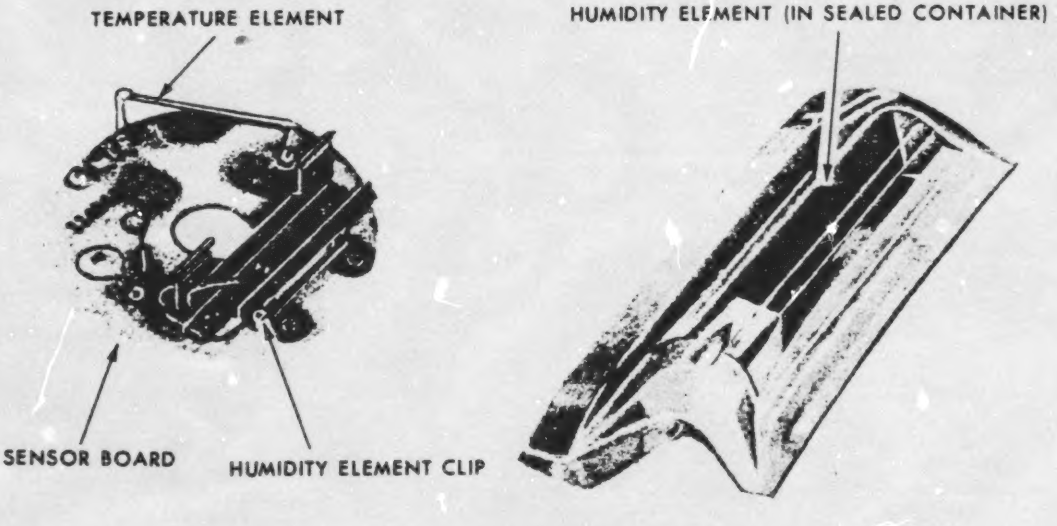


Figure 48. Dropsonde sensor board and humidity element.

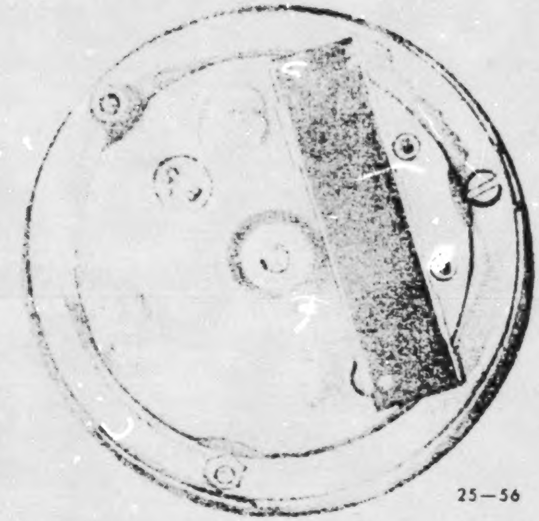


Figure 49. Bottom view of assembled dropsonde.

printed out as a digital record (see fig. 57) for the AWO to process. The airbone observer processes this digital record through an extended number of evaluation steps to arrive at raw parameters of temperature, relative humidity, and pressure. When the AWO arrives at this point, the functions performed by the two airborne systems merge. As you should recall, we discussed the plotting of the WPC 9-31 (A, B, or C) chart earlier in this course. This chart is also used in Weather Recon. One of the things that Weather Recon does with the chart is different, but the basic idea is the same. We know at what millibar (MB) level the aircraft is flying and we know the true altitude of that level. To get the heights of the standard pressure surfaces below the aircraft, we just subtract the distance from one MB level to another on the way down. The rest of the evaluation of the WPC 9-31 chart remains the same as in rawinsonde.

10-17. **Coding and Evaluation.** The coding and evaluation of the dropsonde observation is done according to 9WRWGM 105-1, Vol I. Weather Recon uses the WMO code form of FM36.D as adopted for U.S. Military usage in the manual for rawinsonde code. The code has not been modified, but there are two exceptions that are made to facilitate its use for dropsonde.

10-18. *Coding.* One of the two exceptions is the replacement of the prefix "TEMP SHIP" with the dropsonde indicator groups of "9XXX9 71717." The 9XXX9 group comes from the first group of RECCO code and is coded exactly the same. (See Volume 3, Chapter 1). The 71717 is a key group to indicate that the data was obtained by the use of a dropsonde. The other exception is the way in which the time of the observation is encoded. The dropsonde operator codes the time to the nearest quarter hour. (See fig. 58). For example, if the time of the observation is 0021Z on the 2nd day of the month,

U.S. AIR FORCE
25-57

Figure 50. WC-130 aircraft, "hurricane and typhoon penerator."

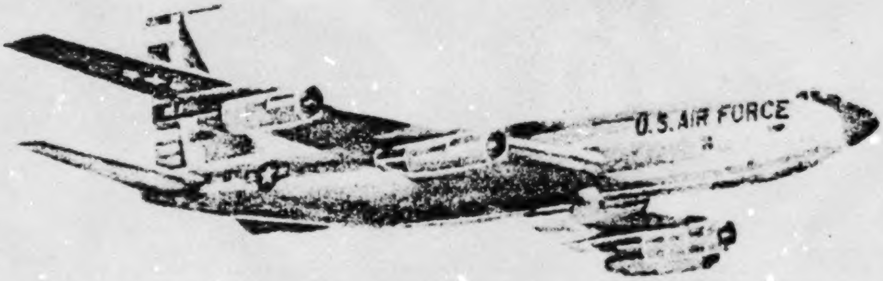

U.S. AIR FORCE

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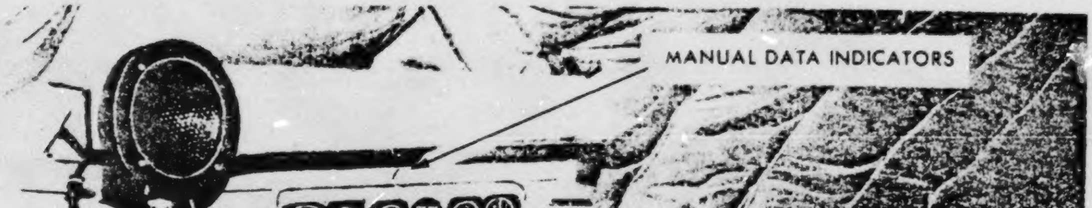
Figure 51. WC–135. "Weather reconnaissance aircraft.


MANUAL DATA INDICATORS
HORIZONTAL SUBSYSTEM CONTROLS
DISPENSER CONTROL PANEL
TELEPRINTER

25-59

Figure 52. AN/AMQ–25 system console.

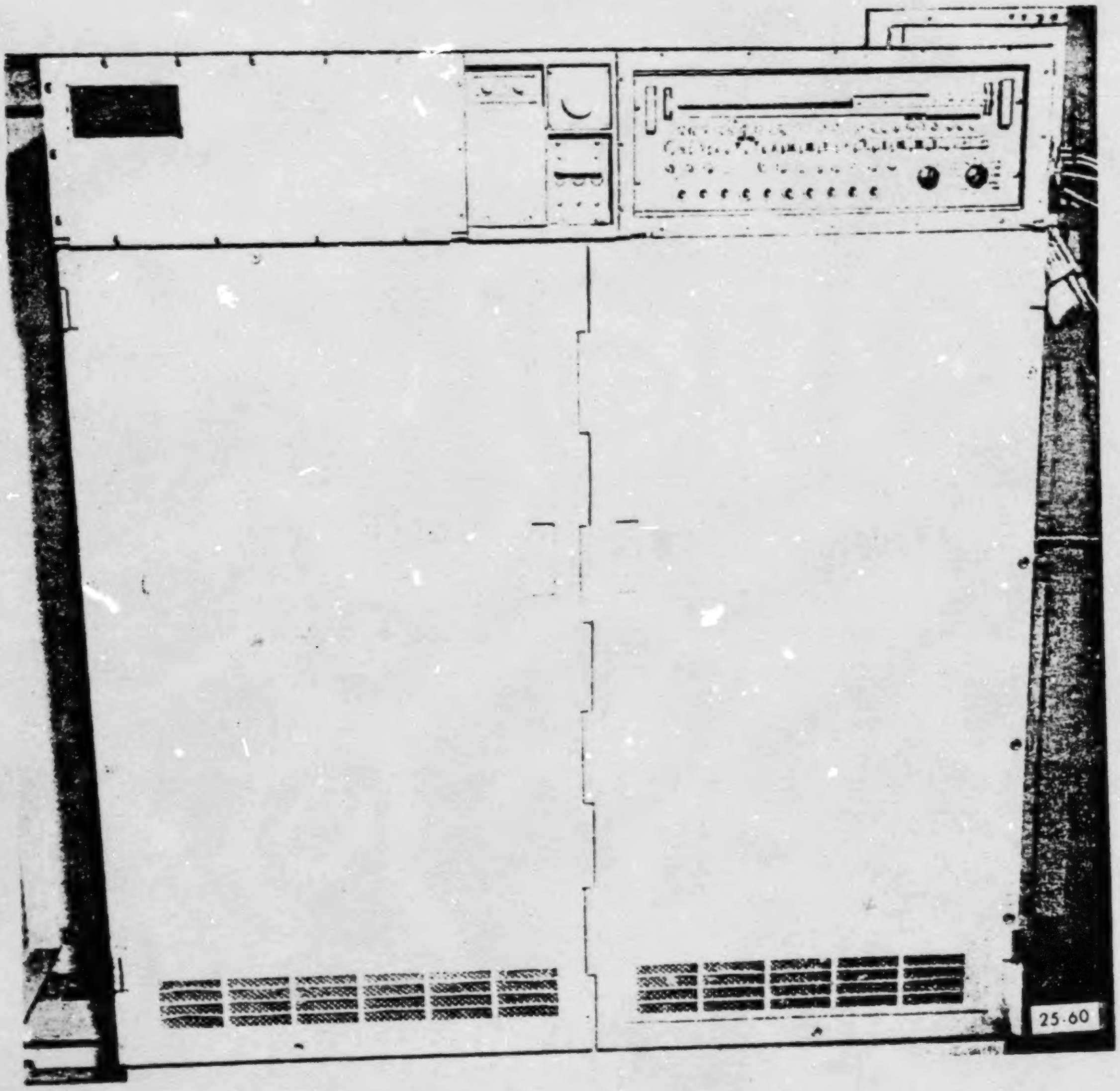


Figure 53. CP-821/ASQ-25 digital data computer.

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the first group after "TT" would be 0225/ in the dropsonde observation. The rest of the code is basically the same, except that the wind groups are omitted from the code. A method of determining winds is under research and development and is expected to be included in the next system update. An example of a completed dropsonde observation is shown below.

```
URPA RJTD 020205
AIR FORCE ROBIN SERRIA OBS 3 DROP
97779 71717
TT 0276/ 99420 11550 16525 99024 12000 00202 10800
  85541
06666 70120 00261 5573 151// 88999 77999
VV 0276/ 99420 11550 16525 00024 12000 11882 03600
  22850
0666 33800 06065 44616 7162 55592 08758 66500
  151// 51515
10168 05950
```

10-19. *Evaluation.* An ambitious Quality Control program exists throughout the dropsonde program. Not only is the quality of the observations themselves controlled, but the quality of the systems and the people assigned to the units are also. Quality Control of an observation begins at the time the observation is finished. When the AWO finishes the observation and before it

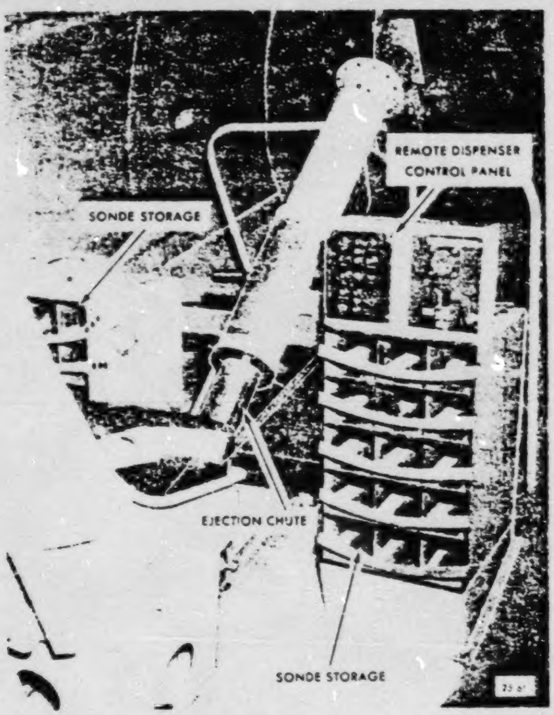


Figure 54. Vertical subsystem.

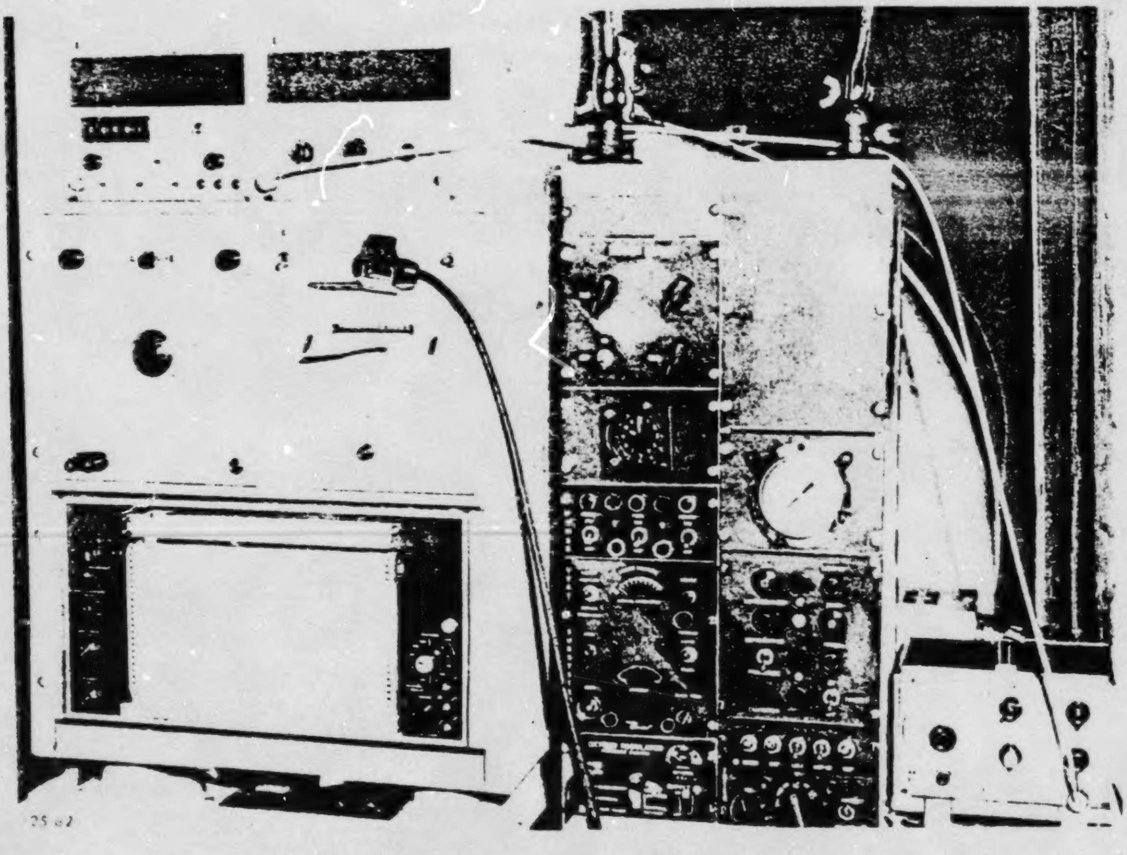


Figure 55. AN/AMQ-29 system console.

is sent, he gives the observation to the aerial reconnaissance weather officer (ARWO). The ARWO then checks the quality of the drop and releases the observation for transmission. After the flight, the quality of the observation is again examined by a highly qualified observer who is assigned the additional duty of Quality Control NCO. This is not the last step though. Five dropsonde observations a month from each squadron are sent to the 9th WRWG to be evaluated for quality. This is the last step in the program before the observations are sent to ETAC.

10-20. This just about wraps up the dropsonde observation. There are much more complicated procedures involved in the total picture of dropsonde, but these procedures are beyond the scope of this CDC. Although we have only touched the surface of this interesting and challenging duty, we hope we have whetted your appetite for more. AWS's 9th WRWG has the prime responsibility for all of Air Force's World-Wide Weather Reconnaissance program. If you can meet the challenge, you may find a voluntary tour in Weather Reconnaissance an interesting experience.

10-21. Before proceeding to Chapter 4, turn to your Workbook and answer the chapter review exercises for Sections 9 and 10 of Chapter 3

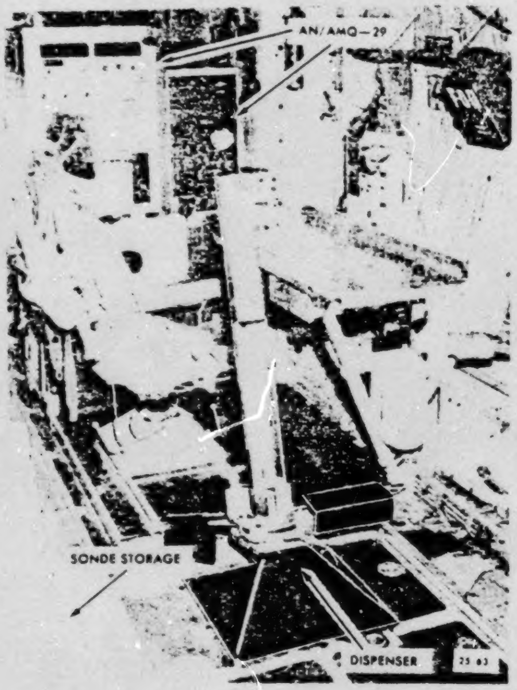
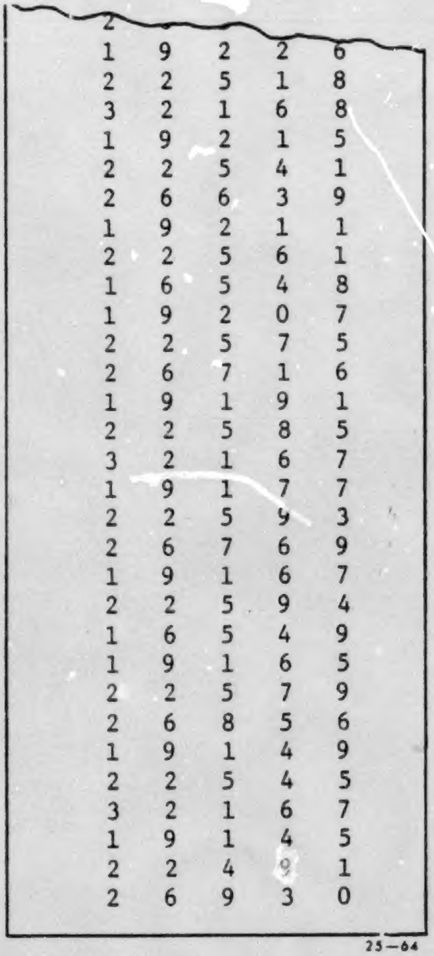


Figure 56. AN/AMQ-29 dispenser and sonde storage.



```
2
1  9  2  2  6
2  2  5  1  8
3  2  1  6  8
1  9  2  1  5
2  2  5  4  1
2  6  6  3  9
1  9  2  1  1
2  2  5  6  1
1  6  5  4  8
1  9  2  0  7
2  2  5  7  5
2  6  7  1  6
1  9  1  9  1
2  2  5  8  5
3  2  1  6  7
1  9  1  7  7
2  2  5  9  3
2  6  7  6  9
1  9  1  6  7
2  2  5  9  4
1  6  5  4  9
1  9  1  6  5
2  2  5  7  9
2  6  8  5  6
1  9  1  4  9
2  2  5  4  5
3  2  1  6  7
1  9  1  4  5
2  2  4  9  1
2  6  9  3  0
```

Figure 57. Sample AN/AMQ-29 digital record.

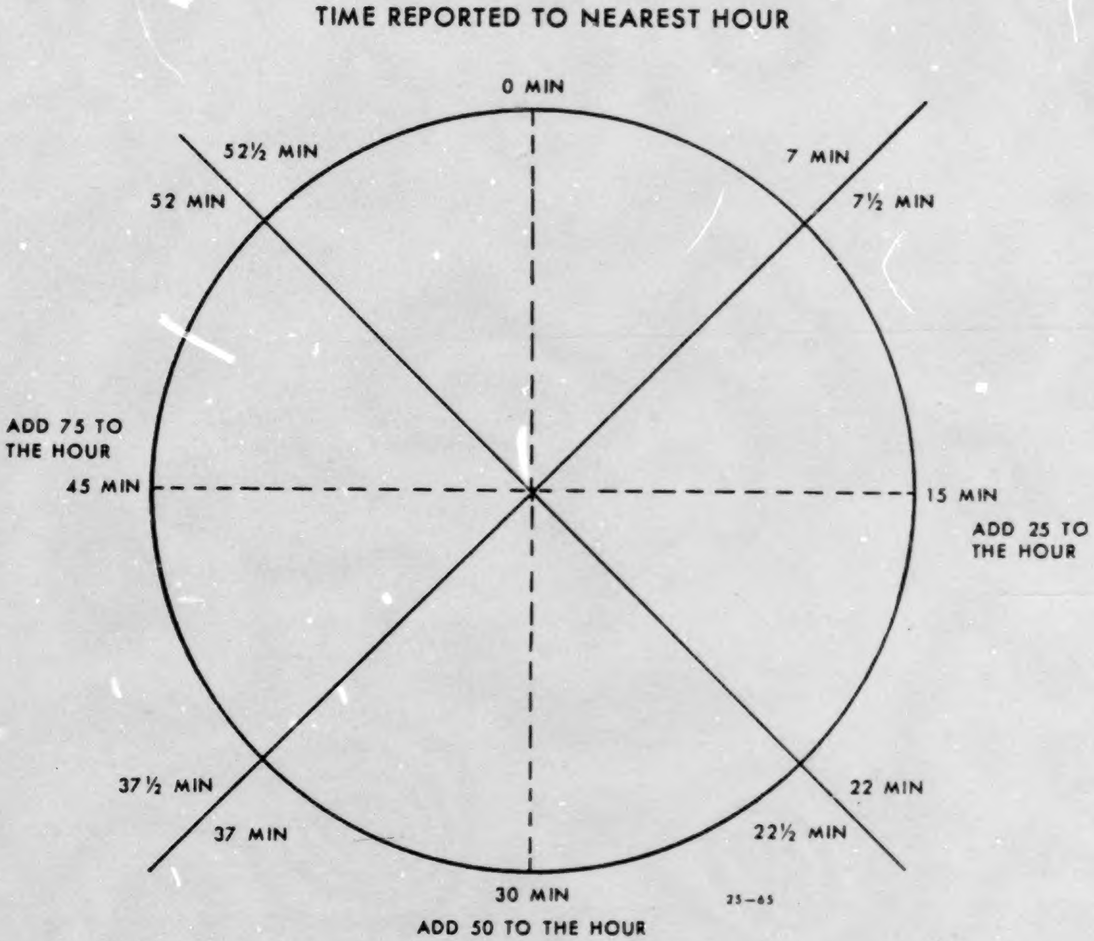

TIME REPORTED TO NEAREST HOUR
0 MIN
52½ MIN
52 MIN
7 MIN
7½ MIN
ADD 75 TO THE HOUR
45 MIN
15 MIN
ADD 25 TO THE HOUR
37½ MIN
37 MIN
22 MIN
22½ MIN
30 MIN
25-65
ADD 50 TO THE HOUR

Figure 58. Time encoding chart.

MODIFICATIONS

Chapter 4 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.